Aspects of Ordovician conodonts and the stratigraphy of Thailand, Malaysia and Tasmania.

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Ordovician conodonts from the Gordon Group, Tasmania.

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Text figures.

Tables.

CHAPTER 4.

The Ordovician in Tasmania.

Introduction.

The Ordovician of Tasmania has been summarized by BURRETT et al., (1984), and BANKS et al., (1989).

The Ordovician siliciclastics of the Denison Group and the limestones of the Gordon Group are distributed only in the western half of Tasmania from the Tamar Valley to the Derwent Valley and to Surprise Bay on the southern coast (Fig. 4.2). They are not found on the north west corner of the island or that part of Tasmania east of the Tamar Fault Zone which divides the West Tasmanian Terrane from the East Tasmanian Terrane (Fig. 4.2).

During the later Ordovician the limestones of the Gordon Group began to be deposited in a north south direction over the early sediments along the west coast of Tasmania (Fig. 4.2). By the Late Arenig to Late–Middle Caradoc(Darriwilian to Eastonian) limestones had been widely deposited over the central to western part of Tasmania.

The Denison Group.

The Denison Group is a sequence of mainly siliciclastic sediments reaching a thickness of 3,390m in the type area of the Denison Range, Tasmania (CORBETT & BANKS, 1975). At Beaconsfield, GEE & LEGGE (1974) recognised a thickness of 280m for the Denison Group in a road cutting. The Denison Group is widely distributed throughout western Tasmania (STAIT 1981). The dominantly carbonate Gordon Group conformably overlies the Denison Group (Figs. 4.3, 4.4. and Fig. 4.7).

The Gordon Group.

CORBETT & BANKS (1974) defined the Gordon Subgroup as . . . . " that sequence of marine limestone with lesser siltstone and sandstone lying conformably between the Florentine Valley Formation below and the Westfield Beds above." "The Gordon Group of Tasmania is considered to be the most complete Ordovician carbonate succession in Australia." (ZHEN & WEBBY 1995, p. 275).

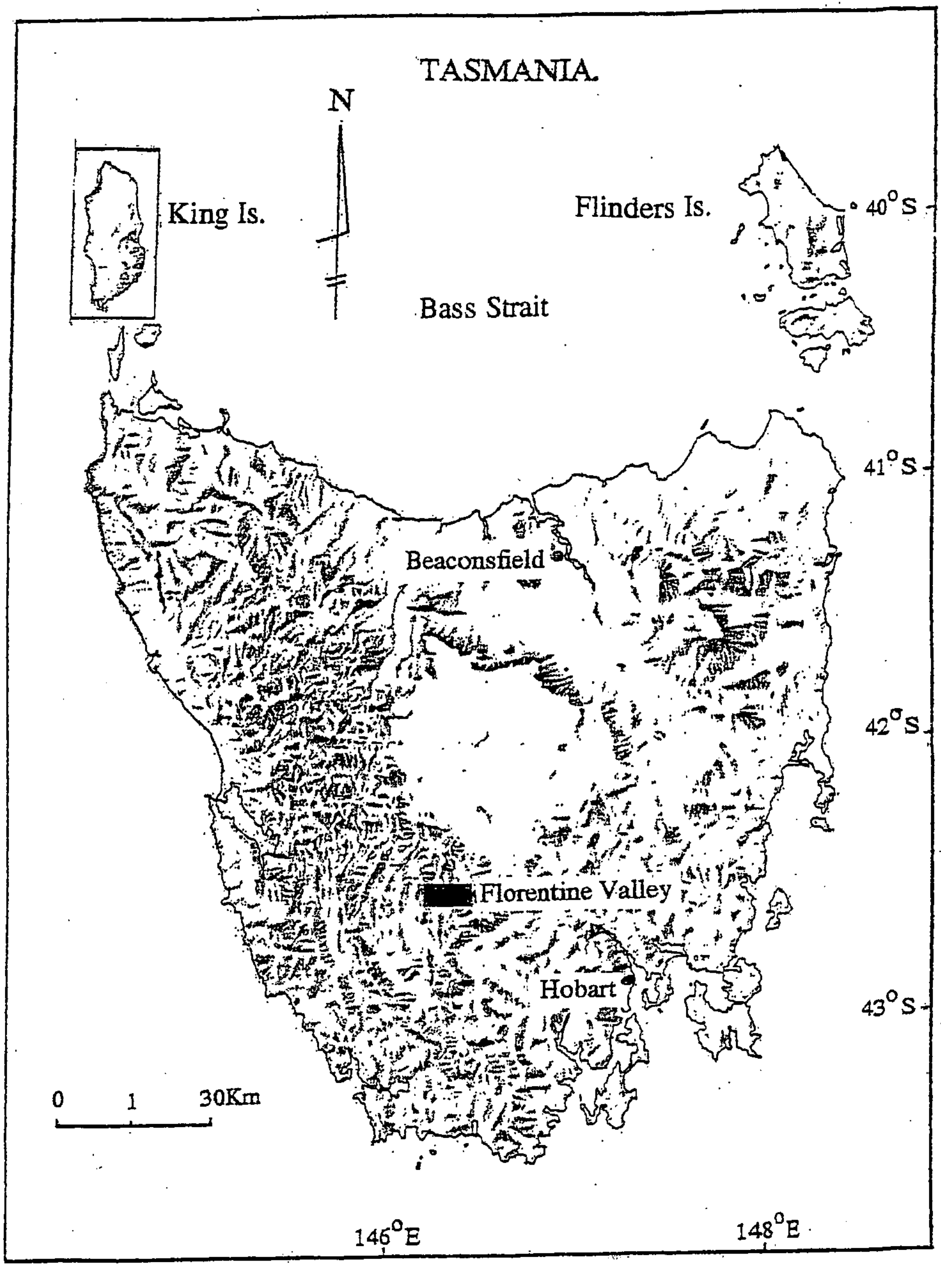
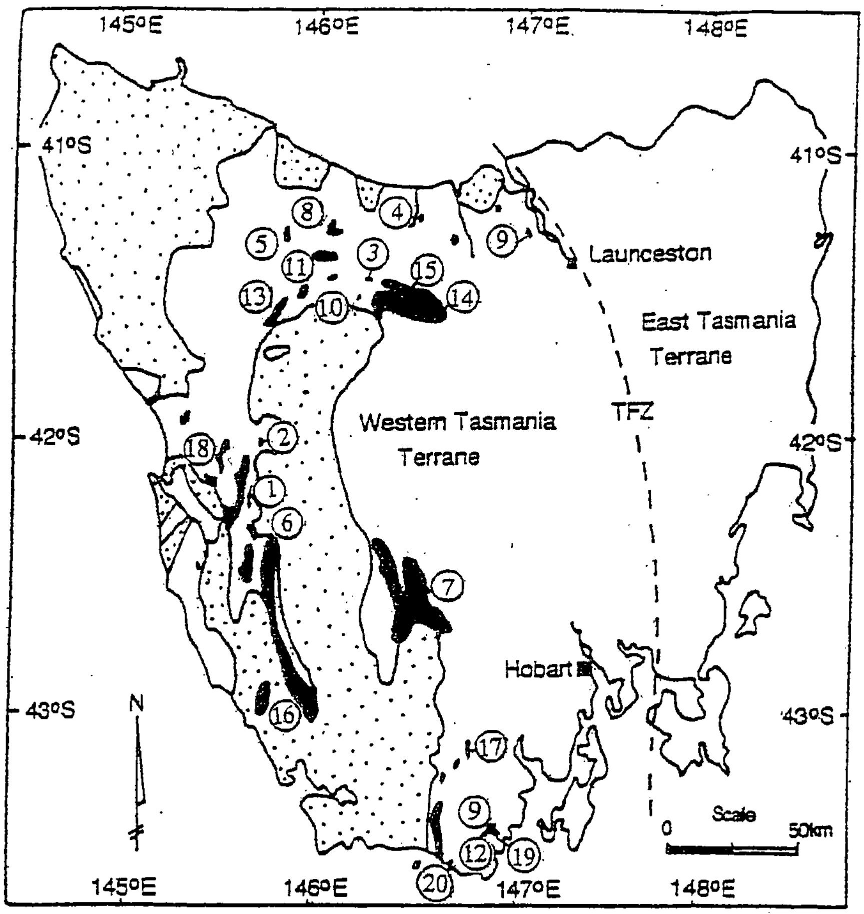


Fig. 4.1. Relief map showing the position of the Florentine Valley near Maydena and of Beaconsfield in northern Tasmania.
Scale 1 cm. = 30 km approx.
From the Gordonvale Map 4428, TASMANIA. 1, 25000. Edit. 1 (1988).
TASMAP Lands Parks and Wildlife. Tasmania.

Fig. 4.2. Distribution of the localities of the main sites of the Gordon Group of limestones in Tasmania.

1. Andrew River
2. Bubs Hill
3. Moina
4. Eugenana–Melrose–Paloona
5. Hampshire
6. Lower Gordon River
7. Florentine River
8. Gunn's Plain
9. Beaconsfield
10. Lorinna
11. Loongana
12. Precipitous Bluff, southern Tasmania.
13. Vale of Belvoir.
14. Chudleigh.
15. Mole Creek.
16. Giblin River area.
17. Picton River.
18. Zeehan.
19. Lune River (Ida Bay).
20. South coast of Tasmania.

TMZ Tamar Fault Zone.



(black)	Major areas of the Gordon Group carbonates	Ordovician
(dotted)	Main areas of Proterozoic rocks	Precambrian

Fig. 4.2. Map showing the distribution of the Gordon Group (Ordovician) limestones cropping out in Tasmania.
After BURRETT (1978), and BURRETT et al., (1984).

TFZ Tamar Fault Zone

The Gordon Group in the Florentine Valley is 1,900m. thick and is of tropical, mainly peritidal carbonates (RAO, 1997). BURRETT et al., (1984) and LAURIE (1982) recorded a faunal sequences of nautiloids, conodonts, brachiopods, trilobites, stromatoporoids, corals, gastropods, bivalves and bryozoa. BANKS & BURRETT (1980), and BURRETT et al., (op. cit.) noted that these faunas ranged in age from the Middle Arenig to the Edenian or Maysvillian.

Stratigraphy of the Gordon Group Limestone, Beaconsfield, Tasmania.

Introduction.

The Precambrian rocks and the Ordovician carbonates are situated near the eastern margin of the Western Terrane of Tasmania (Fig. 4.2). The terrane corresponds to the Taswegian Terrane of STUMP et al., (1986) and the Van Diemen's Terrane of CONEY et al., (1990).

The town of Beaconsfield is situated upon the Beaconsfield Block that is between the Badger Head Block close to the boundary of the Eastern and Western Terranes and the Tamar River in northern Tasmania (Figs. 4.1, and 4.2). ELLIOTT et al., (1993) noted that the Beaconsfield Block is composed of folded and faulted Palaeozoic rocks which range in age from Cambrian to Devonian. These rocks units are, in turn, overlain by sequences of slightly deformed Late Carboniforous to Triassic sediments. The geological relationships of the formations making up the Denison and the Gordon Groups are shown in Figs. 4.3.

The Denison Group, Beaconsfield, northern Tasmania.

At Beaconsfield the Denison Group is composed of the Cabbage Tree Conglomerate, the Salisbury Hill Formation and the Eaglehawk Gully Formation (Fig. 4.3). The Denison Group has been reported as being within four north–trending belts by GREEN (1957), GEE & LEGGE (1974), KOMYSHAN (1977), HILLS (1982), ELLIOTT et al., (1993), and LEWIS (1998, unpub.).

The Cabbage Tree Conglomerate.

The Cabbage Tree Formation was named by TWELVETREES (1903) and is the oldest formation of the Denison Group. HILLS (1982) considered the Cabbage Tree Formation to be of marine origin formed by a marine transgression from the east. The formation overlies the Blyths Creek Formation which rests on Cambrian sedimentary strata. The Cabbage Tree Formation grades upwards into the Salisbury Hill Formation. The Eaglehawk Gully Formation lies conformably over the Salisbury Hill Formation.

KENNEDY (1971, unpub.) obtained Early Ordovician (*D. deltifer* to upper *P. proteus*) conodonts from limestones in drill cores from the Cabbage Tree Formation at

System	Group	Formation	Lithology and Sedimentary structures
Ordovician	Gordon	Grubb Shale 7-75m	Weakly bedded, laminated, black shale, Contains approx. 1% fine-coarse aggregate of pyrite grains
		Flowery Gully Limestone 90-130m	Light grey limestone with indistinct bedding. Thin, elongated calcite structures. Fine graded calcarenite. Shallow water subtidal environment
	Denison	Eaglehawk Gully Formation 249m	Lies conformably over the Salisbury Formation. Interbedded, light grey to stylolitised limestone and quartz sandstone
		Salisbury Hill Formation 154m	Thin to med. sized beds of conglomerate. Sandstone and parconglomerate. Sediments well sorted.
		Cabbage Tree Conglomerate 57m	Crudely layered conglomeritic unit with sandstones. Dark grey sandstones and clay-shales are interbedded every 5-10m. Shallow water environment.
		Blyths Creek Formation Up to 100m 20m mudstone	Composed of up to 100m of thin, grey limestone. Some areas covered by 20m of mudstone/shale. Limestone shows some degree of recrystallization. Minor quartz and haematite.

Fig. 4.3. Formations and their sedimentary structures within the Denison and Gordon Groups, Beaconsfield, Tasmania.
After BURRETT 1978, unpub.), HILLS (1982), ELLIOT et al., (1993), and LEWIS (1998, unpub.).

Beaconsfield. He considered the conodont fauna of the Cabbage Tree Formation to be very similar to the Lower Ordovician conodont Faunas D and E of ETHINGTON & CLARK (1981). This suggested an age of upper Canadian (lower to middle Tremadoc, *P. elegans*, *O. evae* to lower *P. triangulodus*)

Early Ordovician (Tremadoc to Arenig) fossils have been reported from the Cabbage Tree Formation by GREEN (1957), KENNEDY (1974), BURRETT (1978 unpub.), BANKS & KENNEDY, In: BURRETT & MARTIN (1989). The fossils have been correlated with the lower Denison Group of western Tasmania by GREEN (1957), and BANKS & KENNEDY, (In: BURRETT & MARTIN 1989, pp. 193–194).

The Salisbury Hill Formation.

LEWIS (1998, p. 25, unpub.), defined this formation as "a sequence of interbedded dark grey quartz sandstone and oligomictic granule–pebble conglomerate and conglomeritic sandstone" (Fig. 4.3).

The Eaglehawk Gully Formation.

The lithology of this formation is tabled in Fig. 4.3. It is composed mainly of stylolitised limestone and quartz sandstone. The position of the Eaglehawk Formation is shown in the cross section (Fig. 4.4 and LEWIS 1998, unpub. p. 50).

The Gordon Group, Beaconsfield, northern Tasmania.

The formations forming the Gordon Group at Beaconsfield, northern Tasmania are shown in Fig. 4.3. KENNEDY (1971, unpub. p. 330) recorded conodonts of Tremadoc–Arenig age from thin bands of Gordon Limestone at Beaconsfield. The lower beds of the Gordon Group contain Late Arenig (Early Darriwilian) conodont fauna. GULLINE (1981, In: COOPER & GRINDLEY, (Eds.: 1982) suggested that the upper units of the Gordon Group at Beaconsfield were possibly Upper Ordovician in age. HICKS (1989) measured a thickness of 500m of fossiliferous limestone, minor siltstones, slates and quartz sandstones in the Gordon Group.

The Flowery Gully Limestone.

At Beaconsfield, the Gordon Group is represented by the Flowery Gully Limestone and the Grubb Shale (Fig. 4.3.). The deposit was named by NOAKES et al., (1954). BANKS et al., (1989) measured a section which included 460 m of massive grey limestone that overlies the Eaglehawk Gully Formation the uppermost formation of the Denison Group). KENNEDY (1971, unpub.), BURRETT (1978), KENNEDY, (In: MARTIN & BURRETT 1989, p. 213) and LEWIS (1998, unpub.) have reported Lower Ordovician (Arenig) conodonts near the base of the Flowery Gully Limestone and conodonts of Darriwilian age near the

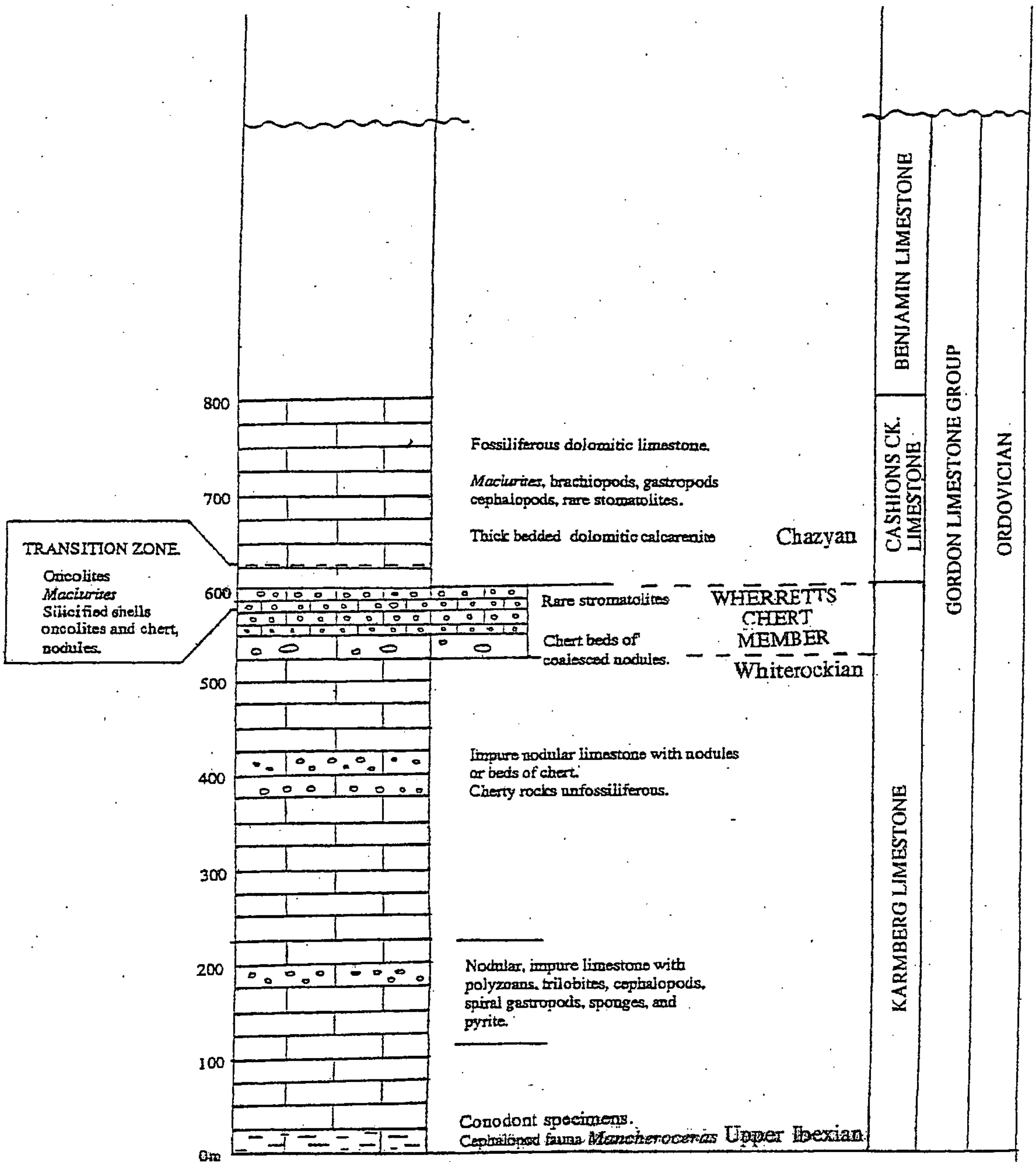


Fig. 4.5. Composite stratigraphic column from Maydena to the Gap in the Florentine Valley.
Conodont specimens were extracted from limestones cropping out at the junction of the Florentine Valley Formation and the the Karmberg Limestone at the Gap.

After WHYTE (1974).

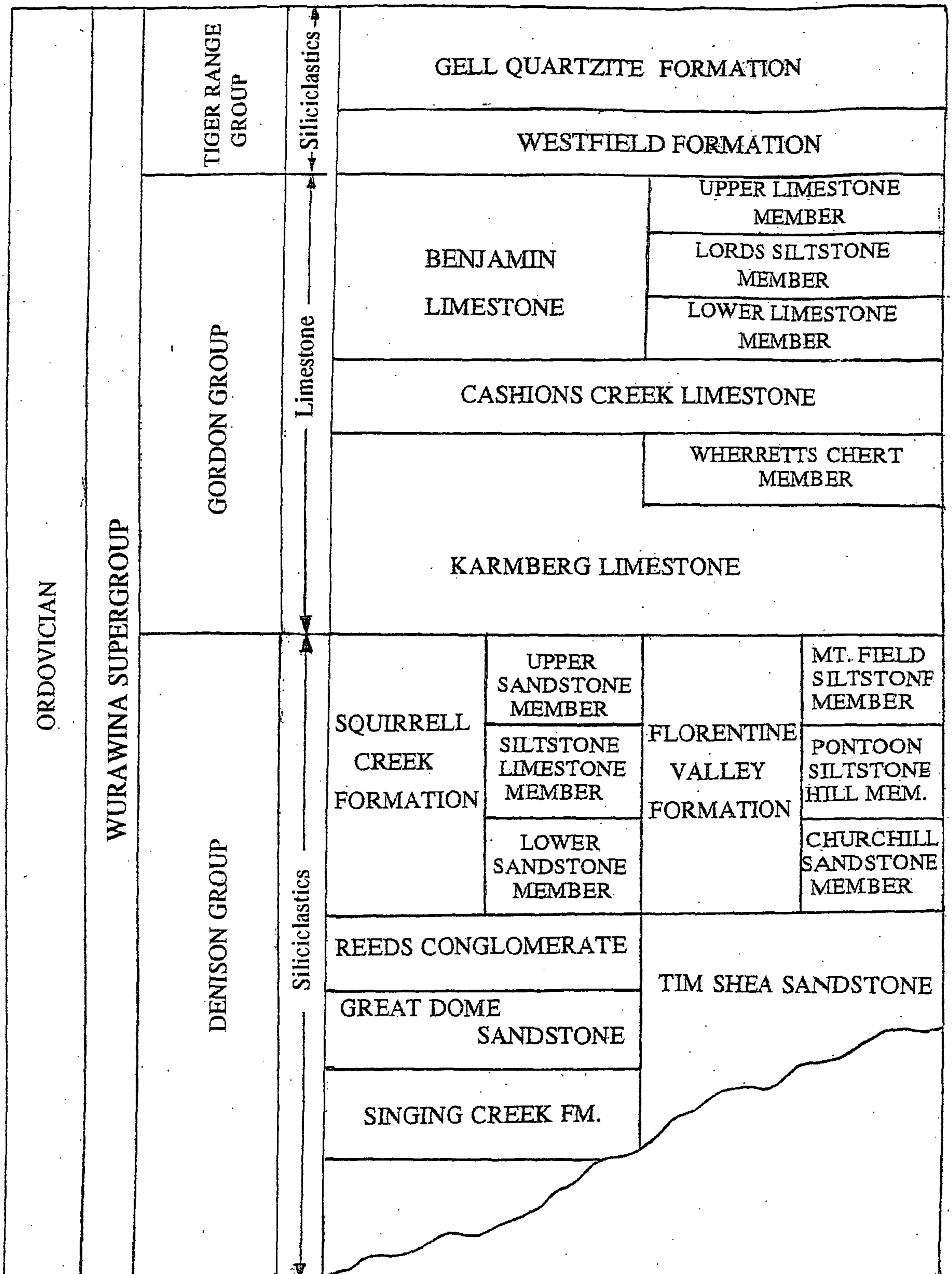


Fig. 4.6. Lithostratigraphic units of the Denison and the Gordon Groups showing their relative positions of the Florentine Valley Formation and the Karmberg Formation.
Modified from CORBETT & BANKS (1974, 1975), CORBETT 1975), BAILLIE (1979), STAIT & LAURIE (1980), LAURIE (1982) and CALVER (1990).

top of the formation.

The Grubb Shale.

The Grubb Shale contains up to 75 m of black shale and was described by GREEN (1957). The sediments show weak bedding laminations (LEWIS 1998, Fig. 4.3.).

Stratigraphy and the Depositional Environment of the Flowery Gully Limestone.

The Flowery Gully Limestone was deposited in a tranquil, sheltered, shallow water, barely subtidal marine environment during the Early Ordovician. This type of environment was suggested by presence of fossil algal bioherms, brachiopods, conodonts, graptolites and stromatoporoids. HILLS (1982) considered that the fauna to be typical Late Arenig (Whiterockian Stage) to very early Darriwilian. KENNEDY (1971, unpub.), BURRETT (1978, unpub.) and HILLS (1982). GREEN (1957), and BURRETT (op. cit.) correlated the Flowery Gully Limestone with the Gordon Limestone immediately above the Denison Group in Western Tasmania.

Ordovician Conodont Succession at Beaconsfield, Northern Tasmania.

Studies of Ordovician conodonts have been carried out by KENNEDY (1971, unpub.), STAIT (1976, unpub.), BURRETT (1978, unpub.) and BURRETT et al., (1983). The Ordovician conodont fauna spans the equivalent of the Whiterockian to Maysvillian (North American Series). Lower Ordovician conodonts have been reported from near the base of the Flowery Gully Limestone KENNEDY (1971, unpub.), BURRETT (1978 unpub.), and KENNEDY (In: BURRETT & MARTIN 1989).

Recently LEWIS (1998, unpub.) extracted conodonts from drill core material taken from the Eaglehawk Gully Formation and the Eaglehawk Formation at the Beaconsfield Mine. The conodont specimens obtained by LEWIS (1998) are discussed in Chapter 5 of this thesis. The range of the conodont species in Chapter 5, (Table 5.4) indicates that some conodonts species such as *Acodus oneotensis, Acodus iowensis,* and *Acodus combsi* are found at the base of the Cabbage Tree Conglomerate at Beaconsfield (*Cordylodus angulatus* Zone). Several conodont species indicates that the *P. elegans* Zone lies within the uppermost part of the Cabbage Tree Conglomerate.

The Florentine Valley Formation.

The Florentine Valley in southern central Tasmania is part of the . . . . "eastern half of the a large synclinorium of folded, Late Cambrian to Early Devonian sedimentary rocks." (CALVER 1990, p. 3, Fig. 4.7). The synclinorium is composed of a shallow shelf sequence defined as the Wurawina Supergroup (Upper Cambrian to Devonian) by BANKS & WILLIAMS (1986) that is widespread throughout western and northern

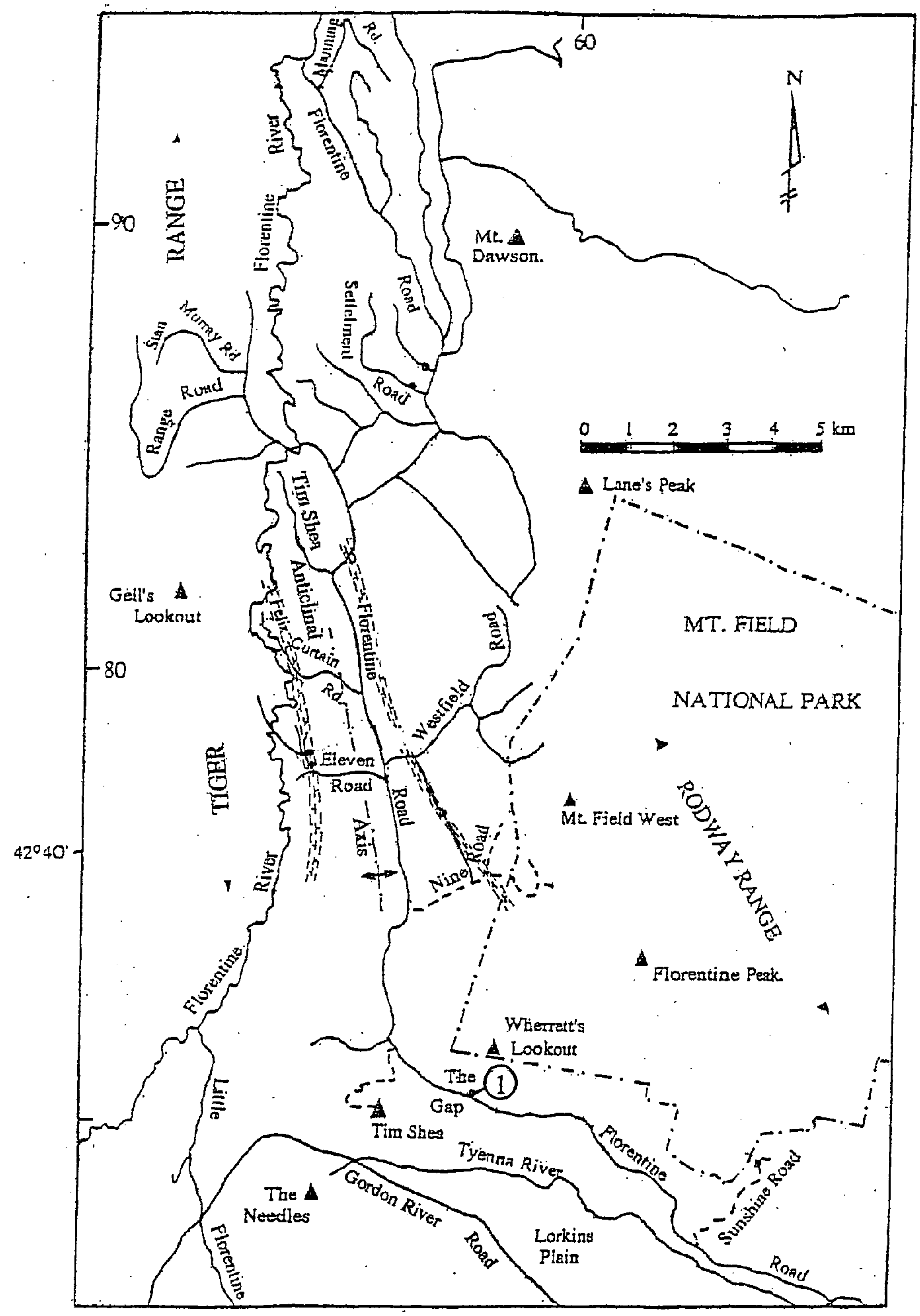


Fig. 4.4. Conodont sampling sites from the Florentine Valley, Tasmania.
1. The Gap, Florentine Valley Road.
Map adapted from LAURIE (1982).

Tasmania. The Wurawina Supergroup is composed of the dominantly siliciclastic Denison Group which, in turn, overlies the dominantly carbonate Gordon Group which is overlain by the dominantly siliciclastic Eldon Group (Fig. 4.6).

The Florentine Valley Formation (Denison Group) lies conformably below the Karmberg Limestone at The Gap. The lithostratigraphy of the Florentine Valley was first established by CORBETT & BANKS (1974) and is shown in Fig. 4.6.

The age of the Florentine Valley Formation.

An associated fauna of trilobites, ostracods, brachiopods and graptolites from the Florentine Valley Formation are assigned to the Late Tremadoc to possibly early Arenig (Lancefieldian, La 1.5 of *Psigraptus* ranging possibly La2 to La3) in JELL & STAIT (1985). The graptolite *Psigraptus* occurs in the La1 to La 2 Graptolite Subzone of Victoria (COOPER & STEWART 1979 and VANDERBERG & COOPER 1992).

The Karmberg Limestone.

The thickness of the Karmberg Limestone is variable, averaging from 550 to 650m at The Gap (WHYTE 1974) and 450m in studies by LAURIE (1982 and CALVER (1990) (Fig. 4.5). LAURIE (op. cit.) measured a thickness of 150m of chert rich limestone in the uppermost part of the Karmberg Limestone that is referred to as the Wherrett Chert Member (Fig. 4.5, 4.6). STAIT (1981) measured a thickness of 180m for this member. Both authors found it difficult to measure the thickness accurately because of the dense bush and difficult terrain.

WHYTE (op. cit.) completed a detailed stratigraphy for the Karmberg Limestone at The Gap (synopsis Fig. 4.5). The basal region is composed calcareous muddy limestone with calcareous siltstone and pyritic material around small chert nodules. Higher in the section the limestone becomes more cherty and nodular with dolomitic and argillaceous material intersecting the bedding. LAURIE (1982) noted that the siltstone stringers became thinner towards the top of the Karmberg Limestone and the micritic material became more oncolitic as the limestone graded into the Cashions Creek Limestone immediately above the Karmberg Limestone.

Fauna from the Karmberg Limestone.

Brachiopods, trilobites, gastropods, cephalopods, nautiloids and rare graptolites have been recorded from the Karmberg Limestone by WHYTE (1974), CORBETT & BANKS (1974), STAIT (1976, 1981), LAURIE (1982) and JELL (1991). These faunas are used to correlate Ordovician strata in Tasmania (Fig. 5.6).

Thirty one genera of Lower Ordovician conodonts obtained from the basal regions of the

Karmberg Limestone at The Gap are discussed in Chapter six of this thesis. (Fig. 4.4.).

The acid leaching of limestone samples from this area also produced gastropod moulds, sponge spicules, ostracods and the pygidia of two trilobite specimens.

Environmental Conditions.

The nature of the sediments and the fauna indicates a comparatively stable environment (WELDON 1974), CALVER 1990, p. 8) suggested that the sediments were deposited in a "tranquil, sublittoral environment for the lower part of the formation . . . with intertidal conditions prevailing in the upper part."

Conodont species including *Scolopodus rex*, *Scolopodus* sp. and *Drepanodus arcuatus* found in Fauna D (ETHINGTON & REPETSKI 1984) are indicative of open water deposits. These species are present in the Ordovician sediments at Beaconsfield and the Karmberg limestone. Elements of *Paroistodus parallelus* PANDER, *Acodus deltatus* LINDSTRÖM *Bergstroemognathus extensus* SERPAGLI and *P. elegans* PANDER tend to be found more intermittently in open shelf and basin deposits. This data infers that during the Early Ordovician warmer, but not tropical marine conditions existed around Tasmania.

Conodont Fauna from the Karmberg Limestone.

Conodont specimens can be used to establish conodont Zones within the Karmberg Limestone (Table 6.5). The *C. angulatus* Zone is indicated by the first appearance of *Diaphorodus ?russoi, Acontiodus iowensis, Acanthodus lineatus, Drepanodus homocurvatus, Rossodus manitouensis, Drepanoistodus basiovalis, Bergstroemognathus extensus, Drepanodus homocurvatus, Paroistodus* sp., *Protopanderodus elongatus* and *Variabiloconus variabilis*. The fauna suggests and age of Middle Tremadoc (*C. angulatus* to *P. deltifer* Zones) for the lower Karmberg limestone. Species such as *Scolopodus rex*, *Scolopodus* sp. and *Drepanodus arcuatus* are found in Fauna D (*D. deltifer* to the uppermost *P. proteus* Zone) of ETHINGTON & REPETSKI (1984).

The appearance of many conodonts species tabled in Table 6.5. (this thesis) clearly indicates the position of the *P. elegans* Zone in sample KARM 6 within the Karmberg limestone. *Juanognathus variabilis* SERPAGLI is known only from the *O. communis* Zone in the western part of the United States within Fauna E of ETHINGTON & REPETSKI (1984). The conodont fauna indicates an open shelf environment. *Semiacontiodus cornuformis* first appears in this Zone.

A number of species including *Reutterodus andinus, Juanognathus variabilis* and

Drepanoistodus forceps have a range that extends to the *M. parva* Zone. Conodont species such as *Cornuodus longibasis* (*A. superbus* Zone) and *Dapsilodus mutatus* (*A. tvaerensis* Zone) are two species that range into the upper Ordovician (Ashgill) into the early Silurian.

Chapter 5.

Conodonts from the Eaglehawk Formation (Lower to Middle Ordovician) Beaconsfield, Northern Tasmania, Australia.

Introduction.

The town of Beaconsfield, Tasmania, is situated on the Beaconsfield Block in the north of Tasmania, (Fig. 5.1). The Eaglehawk Formation is situated on the eastern edge of the Badger Head Block (KOMYSHAN1977) and approximately 1.6km to the south south–east of Beaconsfield (Fig. 5.1).

The Denison Group.

The Denison Group rests unconformably upon Cambrian sedimentary strata at Beaconsfield and underlies the Gordon Group at Beaconsfield. The early Ordovician formations of the Denison Group are the Cabbage Tree Conglomerate, the Salisbury Hill Formation and the upper unit called the Eaglehawk Gully Formation. KENNEDY (1971), GEE & LEGGE (1974) and LAURIE (1991a, 1991b) gave an age of Upper Tremadoc to Lower Arenig for the Denison Group at Beaconsfield.

The Denison Group occurs in . . . "four major, northerly trending belts structurally interlaid with Cambrian strata" (LEWIS 1998). GREEN (1959) noted the varying thickness of the Group in this region and GEE & LEGGE (1974) recorded a thickness of 280m in a road cutting. The lithology and sedimentary structures of the Dension Group at Beaconsfield are tabled in Fig.5.3.

The Eaglehawk Gully Formation.

The Eaglehawk Gully Formation is the uppermost unit of the Denison Group at Beaconsfield and lies conformably over the Salisbury Hill Formation. It is composed of interbedded stylolitized limestone and quartz sandstones.

The Depositional Environment of the Eaglehawk Gully Formation.

The Eaglehawk Gully Formation was deposited within a typically broad, estuarine tidal flat consisting of beds of fine quartz arenite LEWIS (1998, unpub.) crossed by tidal channels infilled by limestone formed from bioclastic grainstone. LEWIS (op. cit.) noted that the total thickness of the limestone in this formation increased in total thickness to the west of the Beaconsfield area. This resulted in the development of off shore carbonate that

System	Group	Formation	Lithology and Sedimentary structures
Ordovician	Gordon	Grubb Shale 7-75m	Weakly bedded, laminated, black shale, Contains approx. 1% fine-coarse aggregate of pyrite grains
		Flowery Gully Limestone 90-130m	Light grey limestone with indistinct bedding. Thin, elongated calcite structures. Fine graded calcarenite. Shallow water subtidal environment
	Denison	Eaglehawk Gully Formation 249m	Lies conformably over the Salisbury Formation. Interbedded, light grey to stylolitised limestone and quartz sandstone.
		Salisbury Hill Formation 154m	Thin to med. sized beds of conglomerate. Sandstone and paraconglomerates. Sediments well sorted.
		Cabbage Tree Conglomerate 57m	Crudely layered conglomeritic unit with sandstones. Dark grey sandstones and clay-shales are interbedded every 5-10m. Shallow water environment.
		Blyths Creek Formation Up to 100m 20m mudstone	Composed of up to 100m of thin, grey limestone. Some areas covered by 20m of mudstone/shale. Limestone shows some degree of recrystallization. Minor quartz and haematite.

Table 5.1. Formations and their sedimentary structures within the Denison and Gordon Groups, Beaconsfield, Tasmania.
After BURRETT 1978, unpub.), HILLS (1982), ELLIOT et al., (1993), and LEWIS (1998, unpub.)

decreased the flow of freshwater sediments into the region. Deeper water conditions are indicated by the presence of bioclastic wackestone at the top of the Eaglehawk Gully Formation where it grades into the Flowery Gully Formation.

Age of the Eaglehawk Gully Formation.

KENNEDY (1971), BURRETT (1978, unpub.), and KENNEDY, In: BURRETT& MARTIN (1989, p. 213), and have reported Lower Ordovician conodonts of Arenig age near the base of the Flowery Gully Limestone and conodonts of Darriwilian age towards the upper part of the Formation. LEWIS (1998, unpub.) described a small, Lower Ordovician conodont fauna from the Eaglehawk Gully Formation.

Although there were very few conodont elements available for discussion in this Chapter it is evident that the fauna ranges through to the Lower Ordovician. The fauna shows an affiliation with Lower to Middle Ordovician conodont faunas from Europe, Argentine, Australia, China, Canada, North Korea, Malaysia and the U.S.A. (Tables 5.4, Pts.1 and 2).

The Lower Ordovician elements of *Acodus combsi* FURNISH, *Acodus oneotensis* FURNISH, *Scolopodus rex* LINDSTRÖM, *Scolopodus gracilis* ETHINGTON & CLARK and *Drepanodus arcuatus* PANDER have been recorded from Beaconsfield.

An element classified as ?*Eucharodus parallelus* BRANSON & MEHL (Plate 5.1, figs. 11–12) has a twist in the cusp and the almost parallel lamellae within the very shallow basal cavity. This feature suggests that the element may be cospecific with *Drepanodus homocurvatus* LINDSTRÖM.

The Middle Ordovician conodont elements from Beaconsfield include the oistodiform elements, and *Juanognathus jaanussoni, Juanognathus variabilis* SERPAGLI and *Protopanderodus varicostatus* SWEET & BERGSTRÖM (Table 5.2).

The Gordon Group.

The Upper part of the Gordon Group is represented by a massive grey limestone named the Flowery Gully Limestone (Table 5.1). NOAKES et al., (1954), BANKS et al., (1989) and KENNEDY (1972, unpub. p. 330) recorded conodonts of Tremadoc–Arenig age from thin bands of Gordon Limestone at Beaconsfield. In later papers GULLINE (1981, 1982, In: COOPER & GRINDLEY, Eds. 1982) suggested that the upper units of the Gordon Group at Beaconsfield were possibly Upper Ordovician. The lower beds of the Gordon Group contain Late Arenig to Early Darriwilian conodont fauna. Several conodont species from Beaconsfield are similar to species from the Lower to Middle Ordovician in Argentina (LEHNERT & KELLER 1993, LEHNERT 1995a and ALBANESI 1998b).

Correlation of the Ordovician conodonts from the Flowery Gully Formation.

The Formation has been correlated with the Mole Creek Limestones (KENNEDY 1972, p. 22), and ranges in age from the early Ordovician to the Middle Ordovician. Conodont studies by GREEN (1957), KENNEDY (1972, unpub.), BURRETT (1978, unpub.) and HILLS (1982) helped correlated the Flowery Gully Limestone with other units within the Gordon Group in Western Tasmania.

The presence of the graptolites including *Retiograptus* and *Pleurograptus* in the Grubb Beds overlying the Flowery Gully Limestone indicates that the Upper beds of the Flowery Gully Limestone may at least Upper Ordovician in age (BANKS & BURRETT 1980, and 1989).

The Depositional Environment of the Flowery Gully Limestone.

The presence of fossil algal bioherms, brachiopods, conodonts, graptolites and stromatoporoids indicates that the Flowery Gully Limestone was deposited in a tranquil, sheltered, shallow water, barely subtidal marine environment during the Early Ordovician (HILLS (1982). The fauna is typical Late Arenig (Whiterockian Stage) to very Early Darriwilian (BURRETT 1978, unpub.).

Conodont Fauna from the Eaglehawk Gully Formation.

Conodonts in this study from the Eaglehawk Gully Formation were obtained by LEWIS (1998) from core samples from the Beaconsfield Mine at Beaconsfield. The small conodont fauna from the Eaglehawk Gully Formation, Beaconsfield is composed of a small number of cosmopolitan species. *Acontiodus propinquus, Acontiodus iowensis, Acodus combsi* and *Drepanodus pervetus* are all short ranging species from the lower Tremadoc (*C. angulatus* Conodont Zone (Table 5.2.).

Systematic Palaeontology.

There are too few conodonts available to determine their age ranges accurately. The lithological sequences and the age/range of the conodont species is shown in Tables 5.2 Identified conodont species and their location is shown in Table 5.2 and Table 5.3.

Table 5.3. Distribution of identified conodont element species from the Flowery Gully Limestone, Beaconsfield, northern Tasmania.

Conodont species		Section and Location										
		C4	C11	C12	C14	C16	C18	C20	C21	C31	Railton	Total
Acodus uncinatus				1								1
Acodus combsi					1							1
Acodus cf. *combsi*					1							1
Acodus oneotensis									1			1
Drepanodus sp. A.							1					1
Drepanodus arcuatus				1								1
Paroistodus proteus ?	S			1								1
Drepanoistodus pervetus							1					1
Drepanoistodus sp. 1.							1					1
D. suberectus				1								1
Eucharodus parallelus ?							1					1
Juanognathus variabilis		1						1				1
J. jannussoni								2				3
Oistiform elements	Sc			1				1				2
	M							1				1
Protopanderodus gradatus				1				1			1	3
Reutterodus andinus										1		1
Scolopodus rex								1		2		3
Scolopodus gracilis								1				1
Totals:		1		6	2		4	8	1	3	1	24

One Sb element from Railton, Northern Tasmania.

Langkawi Islands. One specimen of *Juanognathus variabilis*.

System	Series	Conodont Zones	Formations	Core	Acodus uncinatus	Oistodiform sp.	Drepanodus arcuatus	Acodus combsi	Acodus cf. combsi	Paroistodus proteus	Acodus oneotodus	Drepanoistodus pervetus	Scolopodus gracilis	Reutterodus andinus	Scolopodus rex	Drepanoistodus sp. A	Drepanodus sp.1	Protopanderodus gradatus	Eucharodus ?parallelus	Juanognathus jaanussoni	Juanognathus variabilis
ORDOVICIAN	Llanvirn		Flowery Gully Formation																		
ORDOVICIAN	Arenig	M. parva	Flowery Gully Formation																		
ORDOVICIAN	Arenig	P. originalis	Eaglehawk Gully Formation																		
ORDOVICIAN	Arenig	B. navis	Eaglehawk Gully Formation	C4											●					●	
ORDOVICIAN	Arenig	P. triangulodus	Eaglehawk Gully Formation																		
ORDOVICIAN	Arenig	O. intermedius	Eaglehawk Gully Formation																		
ORDOVICIAN	Arenig	O. evae	Eaglehawk Gully Formation	C20		●							●		●				●	●	●
ORDOVICIAN	Arenig	O. evae	Eaglehawk Gully Formation	C31										●	●			●			
ORDOVICIAN	Arenig	P. elegans	Eaglehawk Gully Formation	C16														●	●		
ORDOVICIAN	Tremadoc	P. proteus	Eaglehawk Gully Formation	C18						●		●				●	●				
ORDOVICIAN	Tremadoc	D. deltifer	Eaglehawk Gully Formation										●								
ORDOVICIAN	Tremadoc	C. angulatus	Eaglehawk Gully Formation	C21							●										
ORDOVICIAN	Tremadoc	C. angulatus	Salisbury Hill Formation	C14				●	●												
ORDOVICIAN	Tremadoc	C. angulatus	Salisbury Hill Formation	C12	●	●	●														

Table 5.4.

Stratigraphic and litholitic units of the Denison and Gordon Groups (Ordovician) showing the location of the conodonts species at Beaconsfield, Tasmania

● Recorded site

Systematic Descriptions:

Phylum: Chordata BATESON 1886
Class : Conodonta EICHENBERG, 1930
Sensu CLARK, 1981

Genus *Acanthodus* FURNISH 1938
Type species: *Acanthodus unicinatus* FURNISH 1938.

?*Acanthodus uncinatus* (FURNISH 1938)
Plate 5.1. fig. 5.

Synomymy:

1938 *Acanthodus uncinatus* FURNISH; p. 337, Pl. 42, fig. 30, Text–fig. 2B.

1964 non *Acanthodus* cf. *uncinatus* FURNISH; LINDSTRÖM, p. 137, Text–fig. 47f, [= *Acanthodus lineatus* s.f.]

1971 *Acanthodus uncinatus* FURNISH; DRUCE & JONES, p. 55–56, Pl. 6, figs.9a–12c, Text–fig. 19b.

1981 *Acanthodus uncinatus* s. f. (FURNISH); ETHINGTON & CLARK, p. 10, Pl. 1, fig. 4.

1982 *Acanthodus uncinatus* (FURNISH); REPETSKI, p. 10, Pl. 1, fig. 4. (*cum. syn.* to 1971)

1994 *Acanthodus uncinatus* (FURNISH); JI & BARNES, p.1376, 1383.

1996 *Acanthodus uncinatus* (FURNISH); JI & BARNES, p. 879, fig. 11, 7–8.

1996 *Acanthodus uncinatus* (FURNISH); LÖFGREN, fig. 8J, M–T

2002 *Acanthodus uncinatus* (FURNISH); PYLE & BARNES, p. 69.

Remarks:
The element is tentatively assigned to *Acanthodus uncinatus* as slight serrations are visible on the lower posterior edge of the element. There is also a slight arching of the basal edge at the anterior end of the element that is similar to the element in REPETSKI (1982 Pl. 1, fig. 4b).

Acanthodus uncinatus is recorded within the *Rossodus* community (subtidal environment) in North America (ETHINGTON & CLARK 1971, 1981, REPETSKI 1982, ETHINGTON & REPETSKI 1984, LANDING et al., 1986 and NOWLAN (1985). The species has also been recorded from this community in Australia (DRUCE & JONES 1971 and JONES 1971).

Age:
DRUCE & JONES (1971) recorded *Acanthodus uncinatus* within the *Cordylodus oklahomensis—C. lindtromi* Assemblage Zone in the Burke River Structural Belt of

Queensland, Australia.

Specimen.
One element from Sample C12, Beaconsfield, Tasmania.

Genus *Acodus* PANDER 1856

Type species: *Acodus erectus* PANDER 1856.

Acodus combsi BRADSHAW 1969.

Plate 5.1, fig. 1.

Synonymy:

1969 *Acodus combsi* BRADSHAW; p. 1147, p. 132, figs. 11, 12, Text–fig. 3I, figs. N, R.

1971 *Acodus combsi* (BRADSHAW); KENNEDY, (unpub.), p. 53, Text–figs. 8, 22, Plate 11, fig. 2.

1971 *Acodus combsi* (BRADSHAW); KENNEDY, p. 53, Text-fig. 8, 22, Pl. 11, fig. 2.

1982 *Acodus combsi* (BRADSHAW); REPETSKI, Pl. 2, fig. 3.

1984 *Acodus combsi* (BRADSHAW); STOUGE, p. 76, Pl. 14, figs. 13-19. (*cum syn.*)

Remarks:
The acodiform (Sc) element is similar to the element described by KENNEDY (1971, unpub. Text–fig. 8, fig. 22) and the gothodiform element of *Acodus deltatus deltatus* LINDSTRÖM, (REPETSKI 1982, Plate 2, fig. 3,). The element is damaged and is tentatively classified as an element of *Acodus combsi* BRADSHAW. The structure of the basal cavity is not present to assist in a more accurate classification of the element.

Age:
Acodus combsi BRADSHAW occurs within the *C. angulatus* Zone (Lower Tremadoc). at Beaconsfield, Tasmania.

Specimen:
Only one specimen was obtained from Sample C14, Beaconsfield.

Acodus cf. *combsi* BRADSHAW 1969

Plate 1, figs. 2, 3.

Remarks:
The two lateral costae are prominent on the specimen. The basal cavity is sub rounded.

Age:
Within the *C. angulatus* Zone (Middle Tremadoc to possibly earliest Caradoc at Beaconsfield.

Specimen:
One specimen from Sample C14.

Acodus oneotensis FURNISH 1938
Plate 5.1. fig. 4.

Synonymy:

1938 *Acodus oneotensis* FURNISH, p. 325, Pl. 42, figs, 26-39.
1964 *Acodus oneotensis* FURNISH; ETHINGTON & CLARK, p. 686.
1964 *Acodus oneotensis* FURNISH; MÜLLER, p.95, PL. 13, figs. 1A, 1B, 8.
1971 *Acodus oneotensis* FURNISH; DRUCE & JONES, p. 56–57, Pl. 12, figs. 3a–7c, Text–fig. 20.
1975a cf. *Acodus oneotensis* (FURNISH); LEE, p. 80, 82, Pl. 1, fig. 3A.
non1982 *Acodus oneotensis* FURNISH; AN, Pl. 1, figs. 21, 22.
1982 *Acodus oneotensis* FURNISH; REPETSKI, p. 12, Pl. 2, figs. 7, 8.
non1985 *Acodus oneotensis* FURNISH; AN, et al., Pl. 2, figs. 2–4.
1987 ?*Acodus oneotensis* FURNISH; AN, p. 119, Pl. 9, figs. 24–26.
1995 *Acodus oneotensis* FURNISH; LEHNERT, p. 68, 69, Pl. 1, fig. 6.
1998 *Acodus oneotensis* FURNISH; LEHNERT et al., Pl. 2, fig 16.
2002 *Acodus oneotensis* FURNISH; PYLE & BARNES, p. 89.

Remarks:
Acodus oneotensis from the Langkawi Islands, Malaysia has been fully discussed in Chapter 3 of this thesis.

Age:
Within the "*Acodus*" *oneotensis* (=*Cordylodus angulatus*) Zone in Australia (LINDSTRÖM 1971, DRUCE & JONES 1971, ZENG et al., 1983, and SHERGOLD et al., 1991).

ETHINGTON & REPETSKI (1984) included "*Acodus* " *oneotensis* in their North American Lower Ordovician Fauna C (*C. angulatus* Zone).

Specimen:
One specimen from Sample C21.

Genus *Drepanodus* PANDER 1856

Type species: *Drepanodus arcuatus* PANDER 1856.

Drepanodus arcuatus PANDER 1856.
emend. VAN WAMEL 1974.
Plate 5.1, figs. 10 and 14.

Synonymy:

1971 *Drepanodus arcuatus* PANDER; LINDSTRÖM, p. 41–42, figs. 4–8.
1974 *Drepanodus arcuatus* PANDER; VAN WAMEL, p. 61, Pl. 1, figs. 10–13.
1994 *Drepanodus arcuatus* PANDER; POHLER, Pl. 2, fig. 1, 2, 4–6.
1995a *Drepanodus arcuatus* PANDER; LEHNERT, p. 82, Pl. 3, figs. 15, 16.
1998b *Drepanodus arcuatus* PANDER; ALBANESI, p. 122–123, Pl. 2, figs. 18–25.
1998 *Drepanodus arcuatus* PANDER; ZHANG, p. 56–90, Pl. 4, figs. 7–11, figs. 15, 16.
2001 *Drepanodus arcuatus* PANDER; RASMUSSEN, p. 70, Pl. 5, figs 4–6.

Remarks:

The element is classified as an M element of *Drepanodus arcuatus* PANDER. The single element has had part of the base and the upper margin of the base and the posterobasal corner destroyed. The single element is very similar to the element reported by KENNEDY (1971, unpub.). The cusp is gently recurved and the central groove extends the full length of the specimen. The posterior basal edge of the cusp appears to be extended in a posterior direction.

Age:

In Argentina *Drepanodus arcuatus* occurs in Fauna A and Fauna C with *Drepanodus* sp. 2, within Fauna C of SERPAGLI (1974). The species has also been found in the *P. proteus* Zone (Sub–zones of *O. elongatus—A. deltatus*), *P. elegans, O. evae, O. intermedius, T. laevis, B. navis, M. parva* to the *E. variabilis* Zones (ALBANESI 1998b). LEHNERT (1995a) suggested an extended range for the species through to the *A.? deltatus—P. proteus* Zone. *Drepanodus arcuatus* from the Huk Formation of Norway (RASMUSSEN 1991) ranged from the *B. navis* to the top of the *E. ?variabilis* Zone.

Drepanodus arcuatus PANDER occurs in the *Paltodus deltifer* Zone of southern China (AN et al., 1985). In Korea the species has an extended range from the lower Tremadoc (*Chosonodina herfurthi—Rossodus manitouensis* Zone through to the upper Arenigian (*Triangulodus dumugolensis* Zone (SEO et al., 1994).

Specimen:
One possible arcuartiform element was obtained from Sample C12, Beaconsfield, Tasmania.

Drepanodus sp. A.
Plate 5.1, fig. 12.

Remarks:
The Sc element is robust and has a pronounced basal edge which is deflected towards the anterior basal corner of the element. The basal cavity is shallow reaching about one third of the element.

Specimen:
Only one element was recovered from Flowery Gully Beaconsfield, Sample C18.

Genus *Drepanoistodus* LINDSTRÖM 1971
emend.. VAN WAMEL 1974.

Type Species: *Oistodus forceps* LINDSTRÖM, 1955.

Drepanoistodus sp. 1. LINDSTRÖM 1971
Plate 5.1, fig. 13.

Remarks:
The element is damaged and the anterior edge of the element appears to have been heavily recrystallised. The element is Sd in shape and is tentatively classified as a species of the genus *Drepanoistodus.*

Specimen:
The element was obtained from Sample C18, at Beaconsfield, northern Tasmania.

Drepanoistodus pervetus NOWLAN 1985
Plate 5.1, figs. 15–16.

Synonymy:

1981 *Drepanodus pervetus* NOWLAN,

1996 *Drepanodus pervetus* NOWLAN, JI & BARNES, p. 874, fig. 4, fig. 11, 12–15, 18–19.

Remarks:
The Beaconsfield element is very similar to Fig.11, (12), that JI & BARNES (1996) have

described from the Survey Peak Formation, Alberta, Canada. The element is a homocurvatiform *a* element (NOWLAN 1981). The cusp of the element shows a slight inward twist and the basal cavity is shallow and elliptical. Growth lamellae are visible within the basal cavity of the specimen.

Age:
Drepanoistodus pervetus NOWLAN has a short time range in the Dumugol Formation of Korea (SEO et al., 1994) ranging from the Middle to Upper Tremadoc (Upper *Chosonodina herfurthi—Rossodus manitouensis* Zone to the Middle *Glyptoconus quadriplicatus* Zone).

Drepanoistodus pervetus NOWLAN from Alberta, Canada ranges through the Ibexian–Tremadoc (JI & BARNES 1996, NOWLAN 1985, BARNES et al., 1991). Specimens from the Survey Peak Formation, Canada had an equivalent age of Fauna C and Fauna D (*C. angulatus* to late *P. proteus* Zone) of ETHINGTON & CLARK (JI & BARNES 1996).

Specimen:
One specimen was obtained from Sample C18.

Genus *Eucharodus* BRANSON & MEHL 1933
Typer Species: *Drepanodus parallelus* BRANSON & MEHL 1933

Eucharodus parallelus? BRANSON & MEHL 1933.
Plate 5.1, fig. 11?

Synonymy:

1933 *Drepanodus parallelus* BRANSON & MEHL; p.59, Pl. 4, Fig. 17.
1933 *Drepanodus parallelus* BRANSON & MEHL; p.58, Pl. 4 , fig. 2.
1978 *Drepanodus simplex* BRANSON & MEHL; p. 457, Pl. 2, fig. 14.
1980 *Eucharodus parallelus* (BRANSON & MEHL); KENNEDY, p. 58–60, Pl. 1, fig. 35–38.
1994 *Eucharodus parallelus* BRANSON & MEHL; POHLER, Pl. 3, fig. 6.
1995a *Eucharodus parallelus* BRANSON & MEHL; LEHNERT, p. 88–89, Pl. 2, figs. 15, 16, 18. (*syn.* to 1991).

Remarks:
The element is similar to the element of *Drepanodus homocurvatus* LINDSTRÖM discussed in BARNES et al., (1970, p. 3.). Both elements have a deep basal cavity and displays parallel lamellae in the basal region. The upper cusp shows a slight twisting

towards the inner lateral side. Because the element appears to be more fibrous it is tentatively classified as an element of *Eucharodus parallelus*.

Age:
Lower Ordovician.
LEHNERT (1995a) recorded the species within the *G. quadriplicatus* to the *P. striatus* Conodont Zone in the La Silla Formation, and the *P. elegans* to the *O. communis* Assemblage Zone in Argentina.

Specimen:
One element from Sample C18.

Genus *Juanognathus* SERPAGLI 1974.

Type species: *Juanognathus variabilis* SERPAGLI 1974.

Juanognathus jaanussoni SERPAGLI 1974
Plate 5.2, figs. 3–6.

Synonymy:

1965 *Acodus* n. sp. ETHINGTON & CLARK; p. 187, Pl. 2, figs. 3, 4.

1981 *Juanognathus jaanussoni* (SERPAGLI); ETHINGTON & CLARK, p. 50, Pl. 10, figs. 12, 13.

1995a *Juanognathus jaanussoni* (SERPAGLI); LEHNERT, Pl. 1, fig. 14, (*Syn.* to 1994).

1998b *Juanognathus jaanussoni* (SERPAGLI); ALBANESI, p. 125–126, Pl. 5, figs. 1–9, Text–fig. 13.

2003 *Juanognathus jaanussoni* (SERPAGLI); PYLE & BARNES, p. 149, Fig. 3.

Remarks:
Several of the elements of *Juanognathus jaanussoni* SERPAGLI (1974) from Beaconsfield show the characteristic rounded posterior face. (Plate 5.2, figs. 3–6, this study). The element in Plate 5.2, fig. 3 also has a slight twist to the upper part of the cusp.

Age:
Juanognathus jaanussoni SERPAGLI has a range from *the O. evae, O. intermedius, M. parva* to the *E. variabilis* (Middle Arenig to Darriwilian) in Argentina (ALBANESI 1998b). *Juanognathus jaanussoni* SERPAGLI occurs in Fauna 1 (*O. evae* to *P. triangulodus*) of the El Paso Formation (REPETSKI 1982).

Juanognathus jaanussoni SERPAGLI has been reported from the base of the *J. gananda* Zone (=Upper *O. communis* Zone) in the Skoki Formation, British Columbia, Canada

(PYLE & BARNES 2003).

Specimens:
Two specimens were recovered from sample C20.
One specimen was recovered from sample C4.

Juanognathus variabilis SERPAGLI 1974
Plate 5.2, fig. 2.

Synonymy:

1967 *Acontiodus* sp. B. IGO & KOIKE; p. 17, Pl. 2, fig. 15, text–fig. 4.

1967 *Scolopodus* sp. A. IGO & KOIKE; p. 26, Pl. 2, figs. 7a, 7b, text–fig. 5–I.

1971 *Paltodus* sp. D. ETHINGTON & CLARK; pp. 67–77, Pl. 2, fig. 7.

1974 *Juanognathus* n. sp. SERPAGLI; Pl. 11, figs. 1a–7c, p. 122, figs. 6–17, text–fig. 8, p. 49.

1976 *Juanognathus* cf. *variablis* (SERPAGLI); STAIT, p. 142, Fig. 37, D, E.

1988 *Juanognathus* sp. WATSON; p. 117, figs 3, 7, 8, 10, 11.

1990 *Juanognathus variabilis* (SERPAGLI); SARMIENTO, Pl. 3, fig. 10.

1990 *Juanognathus variabilis* (SERPAGLI); POHLER & ORCHARD, Pl. 3, fig. 18.

1991 *Juanognathus variabilis* (SERPAGLI) SMITH, p. 41, figs, 23c–d.

1993 *Juanognathus variabilis* (SERPAGLI); LEHNERT, Pl. 1, fig. 15.

1994 *Juanognathus variabilis* (SERPAGLI); POHLER, Pl. 3, fig. 14.

1995a *Juanognathus variabilis* (SERPAGLI); LEHNERT, p. 93, Tab. 3, fig. 4. (*cum syn.*).

1995 *Juanognathus variabilis* (SERPAGLI); WANG & BERGSTRÖM, Pl. 8, fig. 9.

1998b *Juanognathus variabilis* (SERPAGLI); ALBANESI, Pl. 5, figs. 10–14.

2003 *Juanognathus jaanussoni* (SERPAGLI); PYLE & BARNES, p. 149, fig. 3, Fig. 11.21, 11.22.

Remarks:
The basal shape is similar to the elements of *Juanognathus variabilis* SERPAGLI described by SERPAGLI (1974) from the San Juan Formation of South America. The two keel–like lateral costae are evident as short processes. The anterior surface of the cusp of the Beaconsfield specimen is rounded and a deep longitudinal groove is visible for the full length of the specimen. The morphology of the elements show a closer relationship to the Transition Series of *Juanognathus variabilis* SERPAGLI proposed by ALBANESI (1998b).

Age:
SERPAGLI (1974) included *Juanognathus variabilis* in Fauna B (*O. evae* Zone, Lower Arenig) from the San Juan Formation, Argentina. ALBANESI (1998b) suggested a Middle Arenig age (*Oepikodus evae* to the *Oepikodus intermedius* Zone) for the species.

Juanognathus variabilis from Unit 3, Faunule 5 of the Summit Limestone, Mt. Patriarch, New Zealand was reported from the *D. gracilis—S. sexplicatus* Assemblage Zone in New Zealand (WRIGHT et al., 1994).

The species has been reported from the *B extensus* to the Middle *J. gananda* Zone (=Middle to Upper *O. communis* Zone) in the Kechika and Skoki Formations, British Columbia, Canada (PYLE & BARNES 2003).

Specimen:
Only one element was recovered from Sample C20.

Genus *Oistodus* PANDER 1856.

Type species: *Oistodus lanceolatus* PANDER 1856.

Oistodiform elements.
Plate 5.1, figs. 6, 7.

Remarks:
The elements may be M elements of other species. As the elements are damaged it is difficult to accurately ascertain their genus or species. The two Sc and one M elements from Beaconsfield are only basal parts of elements. They do not show the structure or shape of the cusp of the elements.

Age:
WORKUM et al., (1976) noted that their fauna from the Canadian Shield Region ranged in age from the Middle Ordovician to upper Ordovician. KENNEDY (1972, unpub.) noted that *Oistodus* sp. from Beaconsfield in Tasmania ranged from the Lower Ordovician through to the Darriwilian.

Oistodus sp. from ranged from the base of the *Cordylodus angulatus* Conodont Zone through to the *Chosonodina herfurthi—Acodus* Assemblage Zone (Middle to Upper Tremadoc) within the Summit Limestone, Mt. Patriarch, New Zealand (WRIGHT et al., 1991).

Specimens:
One Sc element from Sample C12.
One Sc element from Sample C20.
One M element from Sample C20.

Genus *Paroistodus* LINDSTRÖM 1971

Type species: *Oistodus parallelus* PANDER 1856

Paroistodus proteus? LINDSTRÖM 1955

Plate 5.1. fig. 8.

Synonymy:

1955 *Drepanodus proteus* LINDSTRÖM; p. 566-567, Pl. 3, figs. 18–21, Text–fig. 2a–f, j.

1971 *Paroistodus proteus* (LINDSTRÖM); LINDSTRÖM, p. 46–47, figs 8–10,

1997 *Paroistodus proteus* (LINDSTRÖM); LÖFGREN; p. 922–923, Text–figs. 3H–N,4L–AB.

1998b *Paroistodus proteus* (LINDSTRÖM); ALBANESI, p. 144–145, Pl. 8, figs. 31–34, (*cum. syn.* to 1996).

2001 *Paroistodus proteus* (LINDSTRÖM); RASMUSSEN, p. 109, Pl. 134, figs 1–3.

Remarks:

The element is tentatively assigned to *Paroistodus proteus* as it is similar to the S element in ALBANESI (1998b, Pl. 8, fig.33). The cusp is broad and flattened with pronounced, sharp, posterior and anterior edges. The edges become more pronounced at the basal corners.

Age:

Paroistodus proteus occurs within the *P. proteus* and *P. elegans* Zone in Argentina (ALBANESI 1998b).

Specimens:

One element from Sample C12.

Genus *Protopanderodus* LINDSTRÖM 1971

Type Species: *Acontiodus rectus* LINDSTRÖM 1955a and 1971.

Protopanderodus gradatus SERPAGLI 1974

Plate 5.1. fig. 9, Plate 5.2. fig.7, and 9.

Synonymy:

1974 *Protopanderodus gradatus* n. sp. SERPAGLI; p. 75–77, Pl. 5. figs 5a–58b, Pl. 26. figs 11–15, Pl. 30, figs. 1a, 1b, Text–fig. 17. figs. 8a–11c, Pl. 25, figs. 13–16,

1998b *Protopanderodus gradatus* (SERPAGLI) ; ALBANESI, p. 128-129, Pl. 11, figs 13–16, Pl. 15, figs. 12–13, Text–fig. 14B, (*cum syn.* to 1995a).

Remarks:
The elements are assigned to *Protopanderodus gradatus* because of the pronounced groove on the lateral faces of the elements. The posterior basal posterior corner is missing on the element in Plate 5.1. fig. 9.

Age:
Protopanderodus gradatus ranged from the *P. elegans* to the *E. variabilis* Zone in Argentina (ALBANESI 1988b).

Specimens:
Beaconsfield.
One Sb? element from Sample C16.
One Sa element from Sample C31.

In this study one Sb element has been recorded from the Goliath Quarry, northern Tasmania.

Genus *Reutterodus* SERPAGLI 1974

Type Species: *Reutterodus andinus* SERPAGLI 1974.

Reutterodus andinus SERPAGLI 1974

Plate 5.2, fig. 1.

Synonymy:

1941? *Drepanodus arcuatus* (BRANSON & MEHL); GRAVES & ELLISON, p. 3, 7, Pl. 1, figs. 1, 23?, non. 7.

1974 *Reutterodus andinus* SERPAGLI; p. 79-80, Pl. 17, figs. 9a–d, Pl. 28, figs. 1–9d, Text–figs. 19, 20.

1998b *Reutterodus andinus* (SERPAGLI), ALBANESI, p. 178–179, Pl. 11, figs. 21–28, Text–fig. 34. (*cum syn.* to 1997)

Remarks:
The element is a bibranched element with two lateral processes. The denticles on the lateral processes have been damaged and have been replaced with crystallites.

Age:
In Canada *Reutterodus andinus* SERPAGLI occurs in Early to Middle Ordovician strata (*P. elegans—O. evae* Zone) (POHLER & ORCHARD1990). In Argentina *Reutterodus andinus* SERPAGLI occurs within the *P. proteus—P. elongatus* to *O. evae* Zone (ALBANESI 1998b), the *P. elegans* to *O. evae* Zone (LEHNERT et al., 1997) and within the

Arenig in the Karmberg Limestone in Tasmania.

Specimen:
Only one element was recovered from Sample C31.

Genus *Scolopodus* PANDER 1856
Type species: *Scolopodus sublaevis* PANDER 1856

Scolopodus gracilis ETHINGTON & CLARK 1964
Plate 5.2, fig. 13.

Synonymy:

1941 *Drepanodus gracilis* GRAVES & ELLISON; p. 11, Pl. 1, figs. 3, 12.
1964 *Scolopodus gracilis* ETHINGTON & CLARK; p. 699, Pl. 115, figs. 2–4, 8 9.
1965 *Scolopodus gracilis* ETHINGTON & CLARK; p. 200.
1981 "*Scolopodus*" *gracilis* ETHINGTON & CLARK; p. 100, Pl. 11, figs. 27, 28.
(*cum syn*. to 1979).

Remarks:
The element from Beaconsfield has a long, erect, symmetrical slender cusp. The longitudinal costae are distinct, almost parallel, and meet at the apex of the element. The base of the element is damaged and it is impossible to see if the costae reach the basal margin. Under higher magnification faint striae are evident towards the base of the element at the anterior edge. The costae along the anterior side of the element appear to reach the anterior basal margin is a characteristic feature of the elements of *Scolopodus*.

Age:
Scolopodus gracilis ETHINGTON & CLARK, as *Scolopodus* sp. 1, SERPAGLI was reported in Fauna C (Lower Ordovician) from the San Juan Formation, Argentina (SERPAGLI (1974). SERPAGLI (op. cit.) suggested the *Baltoniodus navis* Conodont Zone to be the uppermost part of the range for the species in Argentina.

The presence of *Scolopodus gracilis* ETHINGTON & CLARK in Fauna D of REPETSKI, (1982) and ETHINGTON & REPETSKI (1984) extending the range of the species to above the *Prioniodus* (*O.*) *evae* Zone. "*Scolopodus*" *gracilis* has been included in a Fauna C Assemblage (Upper Tremadoc to lowest Arenig) in Central Nevada by ETHINGTON & REPETSKI (1984) (*Drepanoistodus deltifer—Paroistodus proteus* Zone). *Scolopodus gracilis* has been recorded from the *Chosondina herfurthi—Acodus* Zone within the Summit Limestone at Mt. Patriarch, New Zealand (WRIGHT et al., 1994).

Specimen:
One specimen from Sample C20, Beaconsfield, Tasmania.

Scolopodus rex LINDSTRÖM 1955
Plate 5.2, figs. 10–12.

Synonymy:

1995 *Scolpodus rex* n. sp. LINDSTRÖM, p. 595–596, Pl. 3, fig. 32.

1978 *Scolpodus rex* (LINDSTRÖM); LÖFGREN, p. 109–110, Pl. 1 figs. 38–39. (*cum syn.*)

1989 *Scolpodus rex* (LINDSTRÖM); KANYGIN et al., p. 121, Pl. XVII, fig. 8, Pl. XXI, figs. 10, 11.

1985 *Scolpodus rex* (LINDSTRÖM); STOUGE & BAGNOLI, p. 25, Pl. 9, figs. 1–6, (*cum syn.*).

1994 *Scolpodus rex* (LINDSTRÖM); LÖFGREN, fig. 7. 1.

1995 *Scolpodus rex* (LINDSTRÖM); ORTEGA et al., Pl. 5, fig. 13.

1994 *Scolpodus rex* (LINDSTRÖM); WANG & BERGSTRÖM, Pl. 7, fig 7.

1998b *Scolpodus rex* (LINDSTRÖM); ALBANESI, p. 133, Pl. 12, figs 14–17.

Remarks:
The fragments of the cusps of the two elements from Beaconsfield, Tasmania show the prominent, strong lateral costae typical of *Scolopodus rex* LINDSTRÖM.

Age:
AN et al., (1985) recorded *Scolopodus rex* LINDSTRÖM within the *Paroistodus proteus –Prioniodus elegans* Zone in the Honghuayan Formation, Hubei District, South China. ETHINGTON & REPETSKI (1984) recorded *Scolopodus rex* within Fauna D, U.S.A. *Scolopodus rex* from within the Gualcamyo Formation ranged through the *Baltoniodus navis—Eoplacognathodus variabilis* Zone (ALBANESI 1998b).

Specimens:
Two fragments of *Scolopodus rex* were obtained from Sample C31.
One fragment of a cusp was recorded from Sample C20.

Plate 5.1

All conodont elements were obtained from core samples taken at Beaconsfield, Northern Tasmania unless indicated otherwise.

Fig. 1. *Acodus combsi* BRADSHAW.

Fig. 1. Outer lateral view of a P element. Sample C12, X125. TUGD128313

Figs. 2–3. *Acontiodus* cf. *combsi* FURNISH.

Fig. 2. Posterior basal view, Sa element. Sample C14, X165 TUGD128314

Fig. 3. Enlarged Posterior basal view. X170. TUGD128314

Fig. 4. *Acodus oneotensis* FURNISH.

Fig. 4. Inner lateral view of basal region of a S element showing the thick cusp and the small basal cavity. Sample C21, X290. TUGD128315

Fig. 5. *Acanthodus uncinatus* FURNISH

Fig. 5. Lateral view of an acodontiform (Sc) element. Sample C12. X 105. TUGD128316

Figs. 6–7. Oistodiform elements.

Fig. 6. Lateral view of an Sd element. Sample C20. X105. TUGD128317

Fig. 7. Lateral view of an M element. Sample C20. X95, TUGD128318

Fig. 8. *Paroistodus proteus* ? LINDSTRÖM 1971.

Fig. 8. Inner lateral view of a damaged S element. Sample C12, X75. TUGD128319

Fig. 9. *Protopanderodus gradatus* SERPAGLI, 1974

Fig. 9. Outer lateral view of an Sb? element. Sample C16, X115. TUGD128320

Fig. 11–12. *Eucharodus parallelus* ? BRANSON & MEHL, 1933

Fig. 11. Lateral view of a possible *a* element. Sample C18, X220. TUGD128321

Fig. 12. *Drepanodus* sp. A.

Fig. 12. Enlarged basal view showing the parallel lamellae within the basal region. Sample C18, X330. TUGD128322

Fig. 13. *Drepanoistodus* sp. 1.

Fig. 13. Inner lateral view of element. Sample C11, X150. TUGD128323

Figs. 10 and 14. *Drepanodus arcuatus* PANDER 1856

Fig. 10. Element showing distortion due to metamorphic processes or diagenetic movement. Sample C21, X110. TUGD128324

Fig. 14. Inner lateral view of element. Sample C11, X150. TUGD128325

Figs. 15–16. *Drepanoistodus pervetus* NOWLAN.

Fig. 15. Outer lateral view of the Sd? element. Sample C18, X100. TUGD128326

Fig. 16. Basal view of the element. Sample C18, X130.

Plate 5.1

All conodont elements were obtained from core samples taken at Beaconsfield, Northern Tasmania unless indicated otherwise.

Fig. 1. *Acodus combsi* BRADSHAW.

Fig. 1. Outer lateral view of a P element. Sample C12, X125. TUGD128313

Figs. 2–3. *Acontiodus* cf. *combsi* FURNISH.

Fig. 2. Posterior basal view, Sa element. Sample C14, X165 TUGD128314

Fig. 3. Enlarged Posterior basal view. X170. TUGD128314

Fig. 4. *Acodus oneotensis* FURNISH.

Fig. 4. Inner lateral view of basal region of a S element showing the thick cusp and the small basal cavity. Sample C21, X290. TUGD128315

Fig. 5. *Acanthodus uncinatus* FURNISH

Fig. 5. Lateral view of an acodontiform (Sc) element. Sample C12. X 105. TUGD128316

Figs. 6–7. Oistodiform elements.

Fig. 6. Lateral view of an Sd element. Sample C20. X105. TUGD128317

Fig. 7. Lateral view of an M element. Sample C20. X95, TUGD128318

Fig. 8. *Paroistodus proteus* ? LINDSTRÖM 1971.

Fig. 8. Inner lateral view of a damaged S element. Sample C12, X75. TUGD128319

Fig. 9. *Protopanderodus gradatus* SERPAGLI, 1974

Fig. 9. Outer lateral view of an Sb? element. Sample C16, X115. TUGD128320

Fig. 11–12. *Eucharodus parallelus* ? BRANSON & MEHL, 1933

Fig. 11. Lateral view of a possible *a* element. Sample C18, X220. TUGD128321

Fig. 12. *Drepanodus* sp. A.

Fig. 12. Enlarged basal view showing the parallel lamellae within the basal region. Sample C18, X330. TUGD128322

Fig. 13. *Drepanoistodus* sp. 1.

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Fig. 14. Inner lateral view of element. Sample C11, X150. TUGD128325

Figs. 15–16. *Drepanoistodus pervetus* NOWLAN.

Fig. 15. Outer lateral view of the Sd? element. Sample C18, X100. TUGD128326

Fig. 16. Basal view of the element. Sample C18, X130.

Plate 1. Beaconsfield.

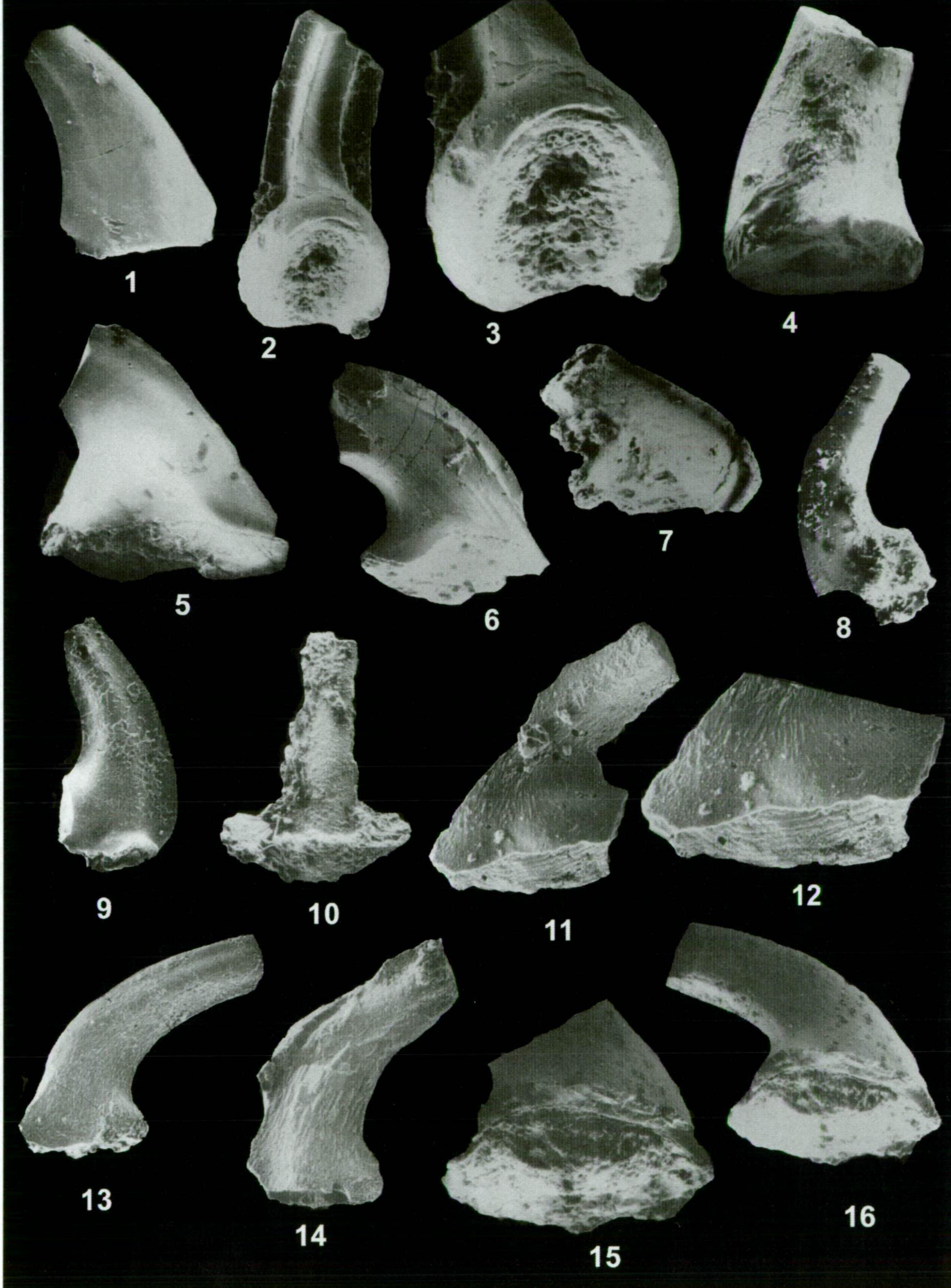

Plate 5.2.

Fig. 1. *Reutterodus andinus* SERPAGLI, 1974

Fig. 1. Posterolateral view oid a possible S element. The denticles of the element have been damaged and replaced with crystals.

Sample C 31. X115, TUGD128327

Fig. 2. *Juanognathus variabilis* SERPAGLI, 1974

Fig. 2. Inner posterior view of a *b* element . Sample C 20, X110, TUGD128328

Figs. 3-6. *Juanognathus jaanussoni* SERPAGLI, 1974

Fig. 3. Outer lateral view of an *e* element. Sample C20, X95, TUGD128329

Fig. 4. Outer lateral view of a *b* elememt. Sample C 20, X95, TUGD128330

Fig. 5. Outer lateral view of a *b* element. Sample C4, X85, TUGD128331

Fig. 6. Inner oblique posterior view of a *b* element .

Element is from the Langkawi Islands, Malaysia. Sample GJO, X95.

TUGD128332

Fig. 7, 9. *Protopanderodus gradatus* SERPAGLI, 1974

Fig. 7. Inner lateral view of an Sa element. Sample C31, X125. TUGD128333

Fig. 9. Inner lateral view of an Sb element.

This specimen is from the Goliath Quarry, Railton, northwest Tasmania. X215. TUGD128334

Fig. 8. *Protopanderodus insculptus* BRANSON & MEHL.

Fig. 8. Inner posterolateral view of an *e* element.

Sample C12, X 130. TUGD128335

Figs. 10–12. *Scolopodus rex* LINDSTRÖM.

Fig. 10. Inner lateral view of part of a cusp of a *b* element

Sample C31, X 105. TUGD128336

Fig. 11. Inner lateral view of part of a cusp of a *b* element.

Sample C20, X 100. TUGD128337

Fig. 12. Inner lateral view of part of a cusp of an *a* element.

Sample C20, X 145. TUGD128338

Fig. 13. *"Scolopodus" gracilis* ETHINGTON & CLARK

Fig. 13. Outer lateral view of an *a* element showing the distinguishing costae.

Sample C 20, X145. TUGD128339

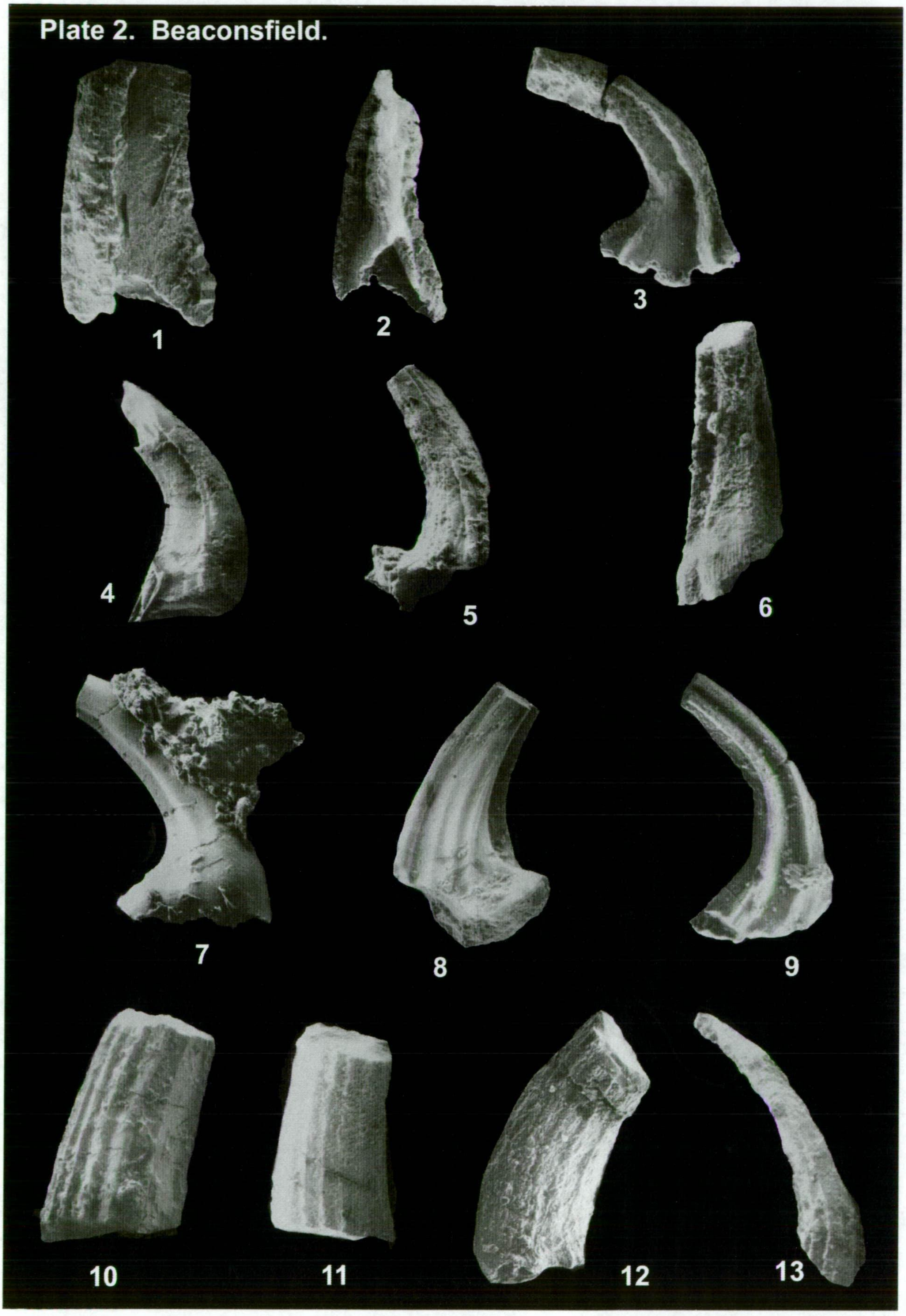
Plate 2. Beaconsfield.
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Chapter 6

Lower to Middle Ordovician conodonts from the Karmberg Limestone, Florentine Valley, central southern Tasmania.

Introduction.

The Florentine Valley is a broad valley located approximately 60 km northwest of Hobart, 5 km north west of the town of Maydena, and to the west of the Mt. Field National Park (Fig. 6.1).

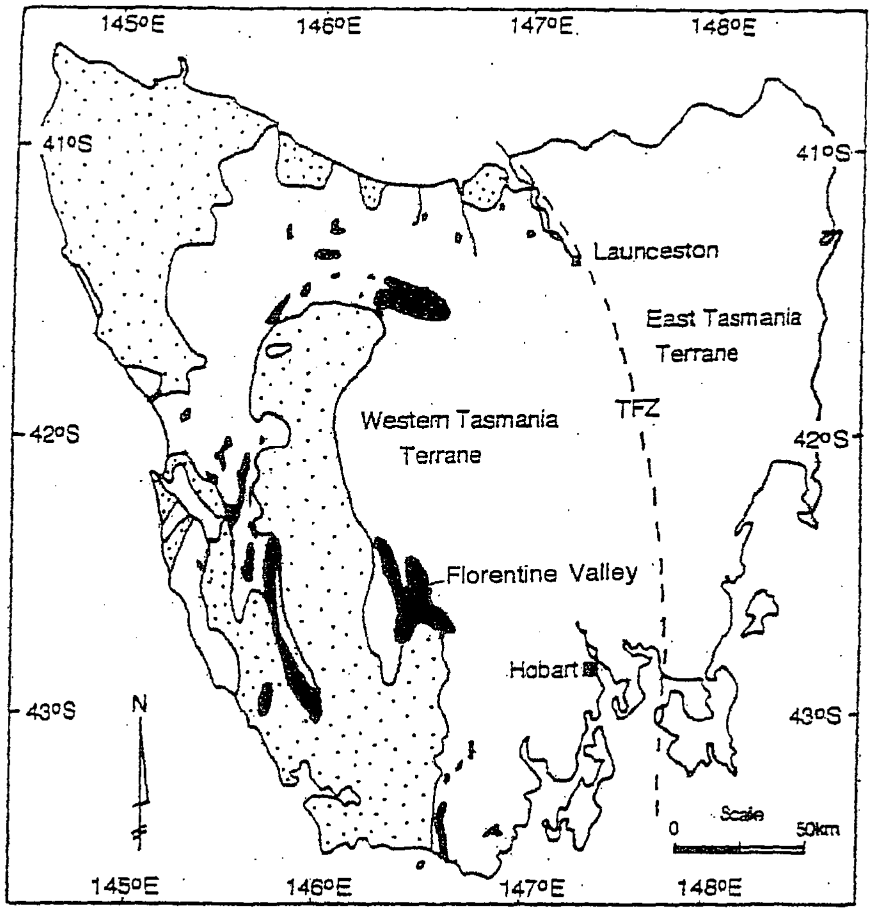
The Florentine River and its tributaries have dissected the limestone sequences above the uppermost part of the Florentine Valley Formation. This has provided good exposures of limestone along the Florentine River Valley. The Florentine Valley Formation is found within a large synclinorium that has a NNW to SSE orientation (Fig. 6.2). Access to the Florentine Valley is along well made gravel, logging roads (Fig. 6.3). The quality of some of the roads branching off the main road has deteriorated with lack of use. A high regional rainfall ensures that the regeneration of ground cover is rapid and much of the limestone cropping out along the roads is now inaccessible.

The Florentine Valley Formation.

The Florentine Valley Formation is the uppermost unit of the Denison Group. The Karmberg Limestone is the lowest member of the Gordon Group within the Florentine Valley and lies directly above the Denison Group. Much of the lithology of the Gordon Group has documented by CORBETT (1964, 1970), CORBETT & BANKS 1974), WHYTE (1974) and STAIT & LAURIE (1980) (Fig. 6.4).

Age of the Florentine Valley Formation.

The invertebrate fauna of the Florentine Limestone is diverse. Initial palaeontogical and biostratigraphic studies were made by CORBETT (1964). Other Ordovician invertebrate fauna including trilobites, inarticulate and articulate brachiopods, ostracods, conodonts, cystoids, gastropods, graptolites and chitinozoa have been documented by STAIT (1976), and CORBETT & BANKS (1974, In: CALVER 1990, p. 8). Studies of nautiloids (STAIT 1981, 1988), and articulate brachiopods (LAURIE 1982) have assisted in the correlation of the geology of the Denison and the Gordon Groups.



Main areas of the Gordon Group of carbonates Ordovician

Main areas of Proterozoic sediments.

Fig. 6.1. Map showing the distribution of the Gordon Group and the location of the Florentine Valley in Tasmania.
After BURRETT (1978).

TFZ Tamar Fault Zone

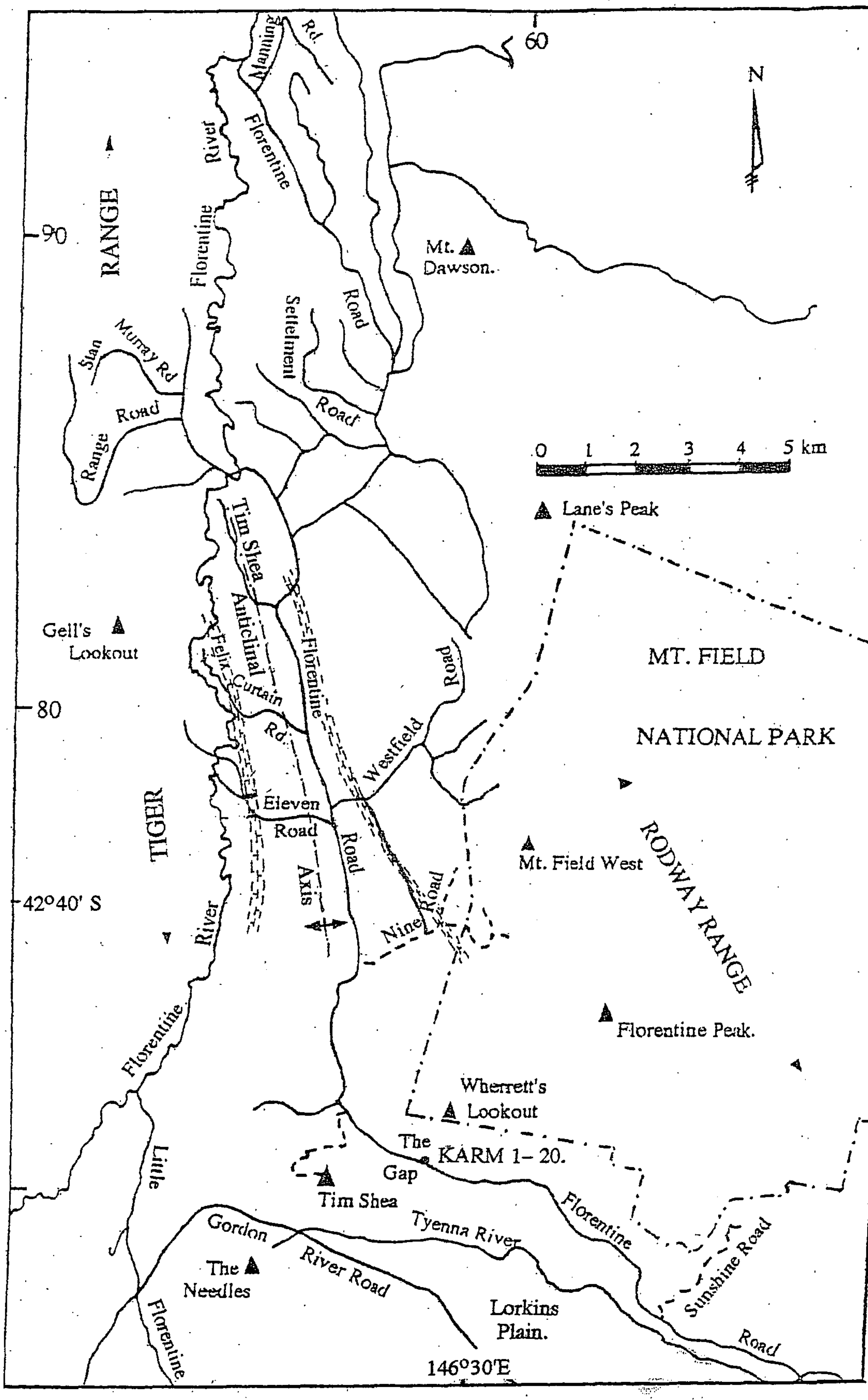


Fig. 6.2 Locality of the Sections taken from the Karmberg limestone cropping out at The Gap, Florentine Valley, Tasmania.

The Gap. Samples KARM 1–20. Map modified from LAURIE (1982).

The presence of *Pycnoceras adamsense, Manchuroceras excavatum, Manchuroceras steani, Yehlioceras robustum, Piloceras tasmaniense, Manchurocerid* n. sp. and *Allocotoceras insigne* clearly define the basal Karmberg in the Florentine Valley at The Gap (STAIT (Text–fig. 3, 1988 and WEBBY et al., 2000, fig. 4.).

The base of the Benjamin Limestone is indicated by the *Tasmanoceras—Hecatoceras —Gouldoceras* Assemblage (WEBBY op. cit., fig. 4.).

Trilobites from several horizons of the Florentine Valley Formation in the Tim Shea area are assigned to the Late Tremadoc to Early Arenig (Lancefieldian, JELL & STAIT 1985). The trilobite *Tasmanocephalus stephensi* occurs at the base of the Karmberg Limestone and suggests a tentative age of middle Arenig (Early Castlemainian) for the uppermost part of the Florentine Valley Formation (STAIT 1976, unpub.) and JELL & STAIT (1985).

The presence of the graptolite *Psigraptus* in the upper part of the Florentine Valley Formation approximates an age of Lancefieldian (La 1.5 Zone of *Psigraptus,* La 2 to La3) (JELL & STAIT op. cit. and VANDENBERG & COOPER 1992). *Psigraptus jacksoni* and the associated fauna from The Needles, in the Florentine Valley Formation are within the Assemblage 3 of STAIT & LAURIE (1983) and the Assemblage OT3 (*Rossodus manitouensis* Zone) (BANKS & BURRETT 1980).

The Karmberg Limestone.

The uppermost part of the Florentine Valley Formation is in contact with the Karmberg Limestone at The Gap but the boundary is indistinct. (Fig. 6.4). The first few metres of the limestone have a very high proportion of clay (calcareous siltstone) occurring within the limestone matrix. The amount of clay decreases upwards through the section from the base of the limestone. The residues obtained by disaggregation of the limestone in acetic acid contain clays, small chert nodules, minor quartz, dolomitic grains and iron minerals.

The Karmberg Limestone is a chert rich limestone that is nodular with silty, dolomitic and bituminous partings that tend to form "rod like structure" (WELDON 1974). WHYTE (1974) suggested a thickness from 500m to 650m for the Karmberg Limestone. Fossils are present but they are not plentiful. The middle portion is poorly exposed due to vegetation cover but some decalcification can be noted in beds along the Nine Road area (Fig. 6.2).

The Wherretts Chert Member is also chert rich, and is imbedded within the upper portion of the Karmberg Limestone (Fig. 6.4). The upper portion is exposed on the western slopes of the Wherrett's Lookout where it grades into a cherty limestone.

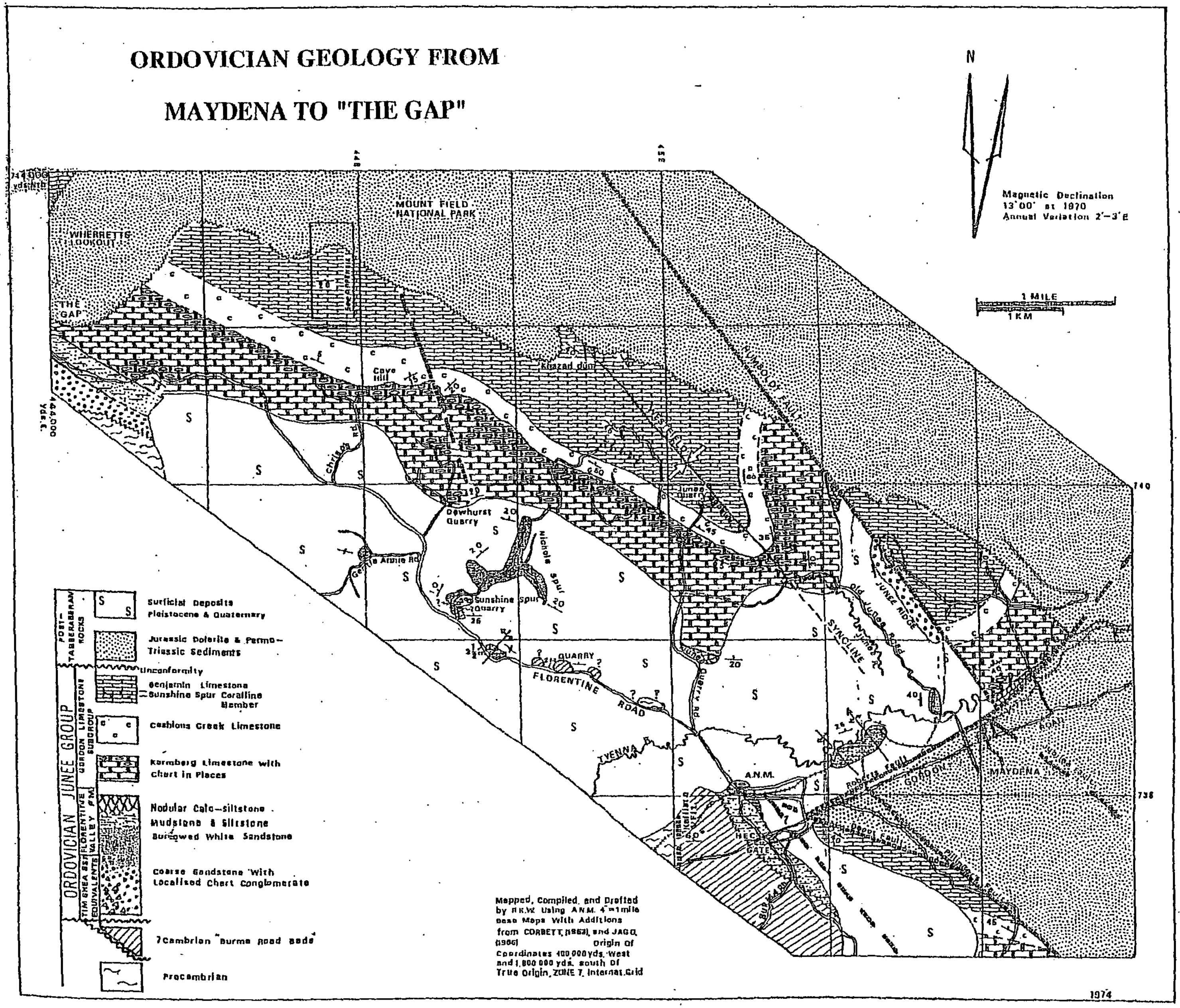


Fig. 6.3. The Ordovician geology of the Florentine Valley from the village of Maydena to The Gap. After CORBETT (1964), JAGO (1972) and WHYTE (1974).

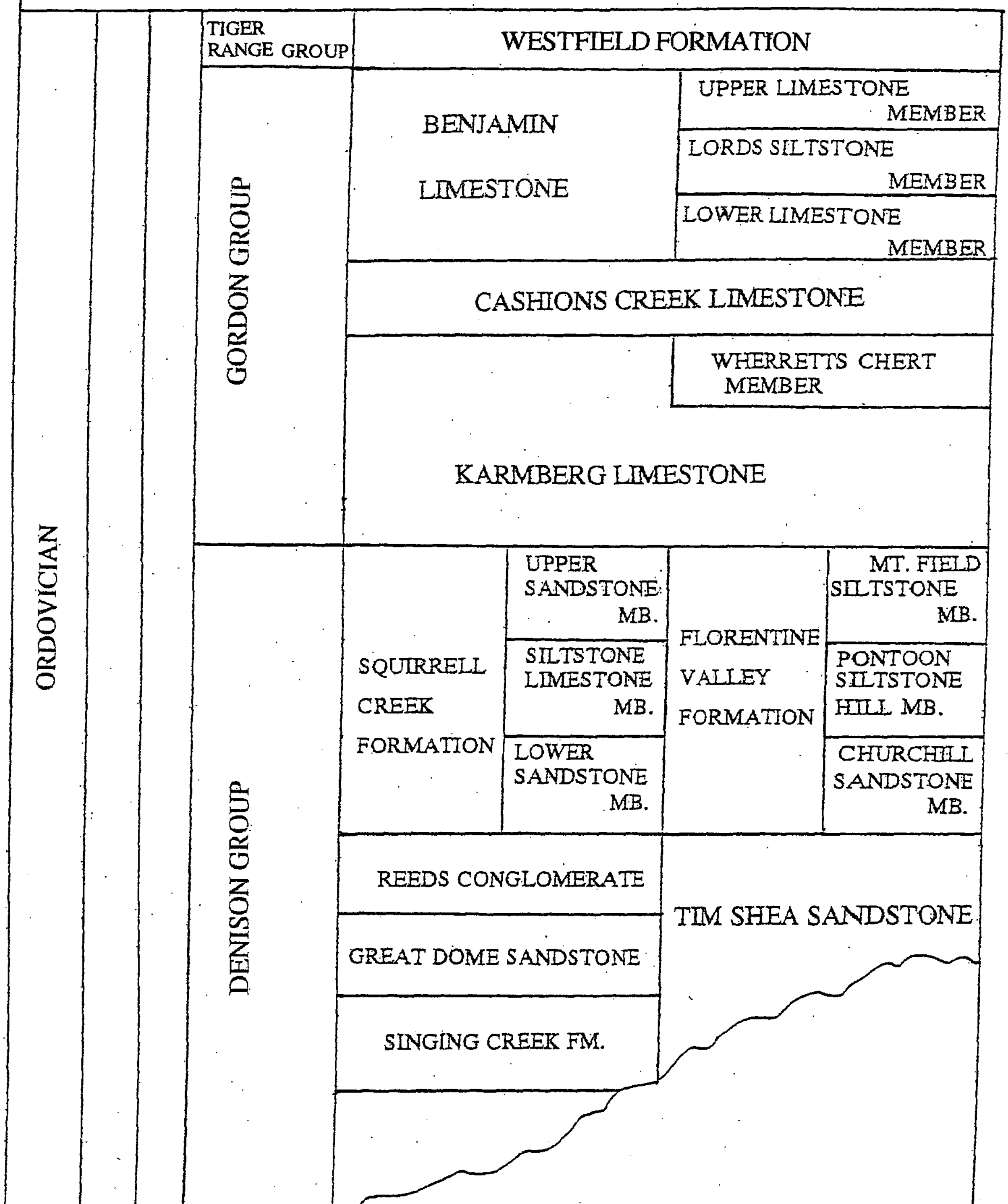


Fig. 6.4. Summary of the stratigraphy of the Denison Group and the Gordon Group in Tasmania.
After CORBETT & BANKS (1974, 1975), BAILLIE (1979), STAIT & LAURIE (1980) and LAURIE (1982).

Section taken from the Karmberg Limestone and limestones cropping out within the Florentine Valley, Tasmania.

Map. WEDGE:	Tasmania. 1,100 000. Sheet 8112. EDIT. 4, 1979.	
Grid References:	578 708 to 579 708	
Latitude:	42° 50'S	Longitude: 146° 29'E

A map of the Ordovician geology of the area from Maydena to The Gap prepared by CORBETT (1964), JAGO (1972), WHYTE (1974), has been reproduced in Fig. 6.3. The relationships of the Karmberg Limestone to the formations immediately above the Karmberg Limestone at The Gap and towards Maydena are shown in Figs. 6.4. and 6.5.

Sampling Procedures.

The Karmberg Limestone is poorly exposed near The Gap. It crops out along the western side of the road cutting as part of a limb of an anticline that rises towards the east. Much of the outcrop was not visible, being covered by soil, and a particularly thick covering of mosses and other forest vegetation. A complete stratigraphic section of the beds within the Karmberg Limestone is extremely difficult to obtain (WELDON 1974).

Sections taken across the Karmberg Limestones were taken along the western edge of the road. The first section was taken from limestones cropping out at approximately two metres above the approximate contact of the Karmberg Limestone with the Florentine Valley Formation. Because the limestones cropped out at very irregular intervals sections were taken at outcrops as they appeared along the strike of the Karmberg Limestone.

The Age of the Karmberg Limestone.

The Karmberg Limestone conformably overlies the Florentine Valley Formation in the Florentine Valley at The Gap. BANKS (1962) suggested an age of Upper Arenig for the Karmberg Limestone. BURRETT (1978, unpub.) and STAIT (1981) recorded conodonts from within the *Prioniodus evae* Zone of LINDSTRÖM (1971) from the oldest Florentine Valley Formation. Work on Tasmanian Ordovician nautiloids by STAIT (1981, 1984) and articulate brachiopods LAURIE (1982) has confirmed the age of the Karmberg Limestone as ranging from the Arenig to Early Darriwilian (Da 1) (*P. elegans* to the *M. parva* Zone).

Conodont Fauna from the Karmberg Limestone.

Some 238 conodont specimens covering 31 genera and 54 species were obtained from limestones cropping out on the western side of the road at The Gap are discussed in the systematics in this chapter. The conodont fauna discussed in this Chapter range from the

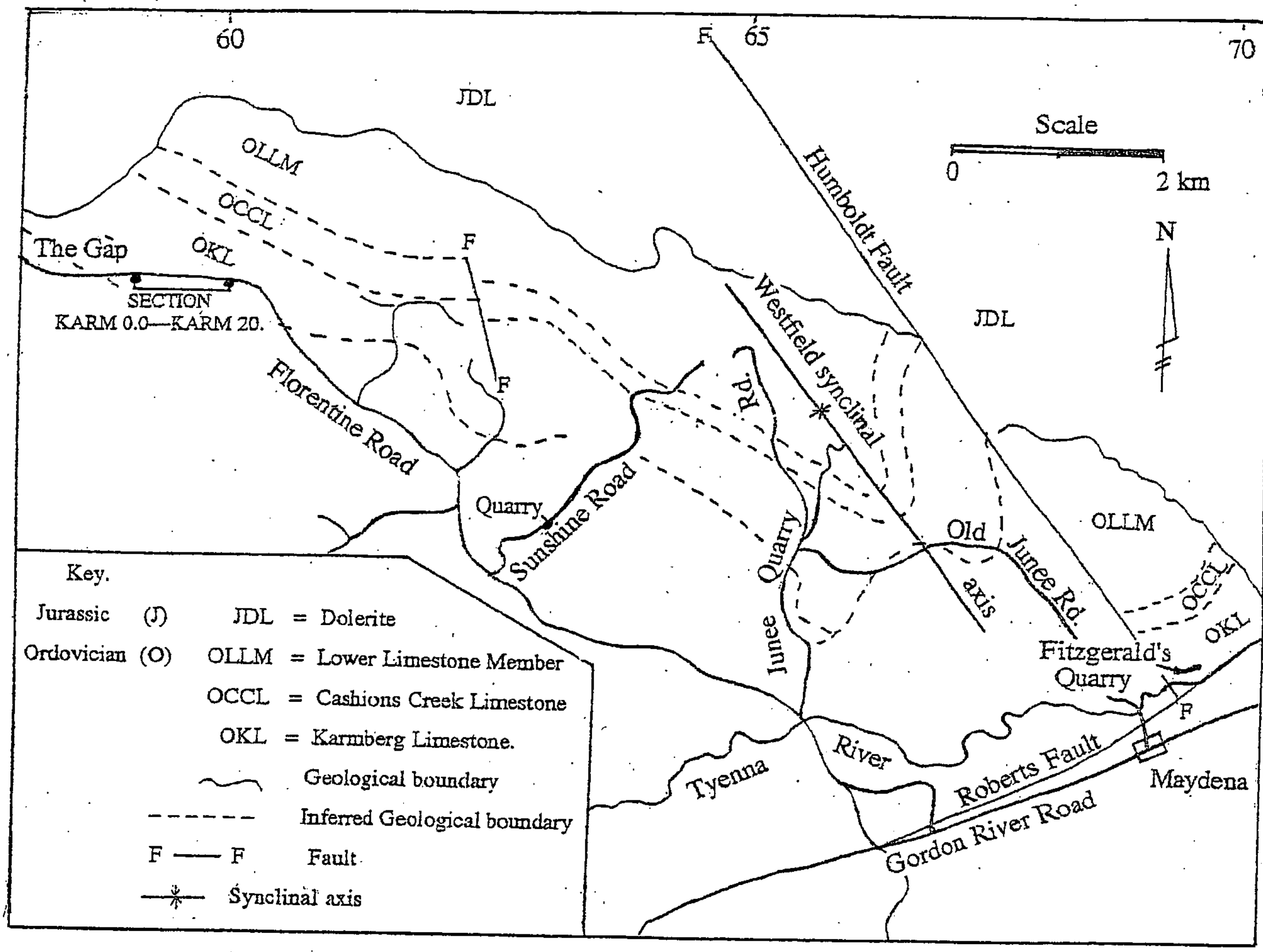


Fig. 6.5. Geology and locality map of the region The Gap to Maydena, Tasmania. The map is modified from WHYTE (1974) and STAIT (1981). The inferred geological bounderies are from STAIT (1981, fig 3.1. unpub.) The localities at which samples were taken from the Karmberg Limestone are indicated.

Upper Tremadoc to the Middle Caradoc (*P. proteus* to the *E. variabilis* Zones).

Conodont species including *Bergstroemognathus extensus, Drepanodus homocurvatus, Teridontus nakamurai, Paroistodus* sp., *Protopanderodus elongatus, ?Tasmanognathus* sp. and *Variabiloconus variabilis* were recorded from in the Sample KARM 1 several metres above contact zone of the Karmberg Limestone with the Florentine Valley Formation at The Gap (Middle Tremadoc, *P. deltifer* to *P. proteus* Zone). Sample KARM 1 at The Gap contained a high proportion of clay and conodont species such as *Teridontus nakamurai* (Lowermost *C. angulatus* Zone). These specimens may have been redeposited into the Lower Karmberg Limestone from the reworked sediments of the upper part of the Florentine Valley Formation.

Older conodonts from the Karmberg Limestone have a longer range based on information from other sources from Argentina and America. (Table 6.5). The range of conodonts such as *Rossodus manitouensis, Oneotodus ?gracilis, Bergstroemognathus extensus, Protopanderodus elongatus* and *Juanognathus variabilis* may occur in the Lower to Middle Tremadoc in the Lower Karmberg Limestone. Table 6.5 indicates a range of these Lower Ordovician conodonts from samples taken at The Gap.

A possible specimen of *Dapsilodus* cf. *mutatus* was obtained from the sample KARM 8 (*M. parva* Zone). Twelve elements of *Cornuodus longibasis* were obtained from most of the sample taken from The Gap. The species ranges from the *P. originalis* Zone through to the Ashgill (Upper Ordovician).

Palaeoenvironment of the Karmberg Limestone.

Carbonate mud was first deposited onto the Florentine Valley Formation which formed the sea floor at that time. Unconsolidated fine clays within the matrix of the limestone formed a limey mud deposit. This material formed the base of the Karmberg Limestone at The Gap. The first four metres of the Karmberg Section is composed of a marly limestone with a high clay content that decreases upwards through the Karmberg Limestone. The next six metres grades into limestones with marl inclusions. Acid residues have produced some faunal debris. The presence of moulds of small gastropods, sponge spicules, crinoid ossicles are common. Only a few conodont elements were obtained from the lower sections at KARM 1. This is possibly due to the clay content due to the admixing of clays from the Florentine Valley sediments during reworking before consolidation occurred.

CAI Values of the Conodonts from the Karmberg Limestone.

All elements appear to have been metamorphosed to some degree as they have a CAI value

Conodont Species	CAMBRIAN	WARENDAN	LANCEFIELDIAN	CHEWTONIAN	CASTLEMAINIAN	YAPEENIAN	DARRIWILIAN	GISBORNIAN	EASTONIAN	EASTONIAN	BOLINDIAN
Global Series		TREMADOC	TREMADOC	ARENIG	ARENIG	ARENIG	LLANVIRN	CARADOC	CARADOC	CARADOC	ASHGILL
North America: Mid Continent Series			WHITEROCK	WHITEROCK	WHITEROCK	WHITEROCK	WHITEROCK	MOHAWK	MOHAWK	MOHAWK	CINCINNATI
North America: Mid Continent Conodont Zones								*P. sweeti*, *P. aculeata*, *E. quadridactylus*	*B. compressa*, *P. undatus*, *P. tenuis*	*B. confluens*, *O. velicuspis*, *A. grandis* / *O. robustus*	*A. divergens*, *A. shatzeri*
Nth. Atlantic Conodont Zones		*Iapetognathus*, *C. angulatus*, *P. deltifer*	*P. proteus* (*D. aff. amoenus*, *P. gracilis*, *Tripodus*), *O. elongatus*	*P. elegans*, *O. evae*	*B. navis* – *T. triangularis*	*P. originalis*	*M. parva*, *E. variabilis*, *E. suecicus*	*B. variabilis*, *P. anserinus*, *A. tvaerensis*: *B. gerdae*	*A. tvaerensis*: *B. alobatus*	*A. superbus*	*Am. ordovicicus*
Acodus russoi				•							
Acontiodus iowensis					•						
Acanthodus lineatus				•							
Drepanodus parallelus							•				
Drepanodus homocurvatus				•							
Teridontus nakamurai		•									
Oneotodus ?gracilis				•							
Rossodus manitouensis				• •							
Drepanoistodus basiovalis				•			•				
Oistodus lanceolatus					•	•	• •				
Scolopodus filosus				•			•				
Variabiloconus variabilis			•								
Glyptoconus quadriplicatus				• •							
Scolopodus krummi				• •							
Reutterodus andinus				• ••			•				
Drepanodus arcuatus			• •								
Bergstroemognathus extensus				• •	•						
Protopanderodus elongatus				•	•						
Juanognathodus variabilis				•			•				
Triangulodus larapintinensis				•	•						
Drepanoistodus forceps			•	•	•		•				
Aurilobodus leptosomatus				•	•						
Appalachignathus sp.			•	•							
Oepikodus evae				•							
Oistodus hunickeni				•							
Protopanderodus cf. *gradatus*				• • •	•		• • ?				
Protopanderodus cf. *P. leei*				•							
Jumudontus gananda				• •	•						
Aurilobodus sp.				•							
Protopanderodus cf. *P. priminus*				• •	•		•				
Scalpellodus tersus				• •							
Scalpellodus cf. sp.. *S. tersus*				•	•						
Scolopodus rex			•	•	•		•				
Paltodus sweeti				• •							
Oepikodus sp.				•							
Oepikodus communis				• •							
Scandodus americanus				•							
Polonodus sp.				• •	•						
Scandodus furnishi				• •							
Protopanderodus rectus				•		•	• •				
Juanognathodus jaanussoni				•	•		• •				
Stolodus cf. *S. stola*				•	•						
Scolopodus floweri				•		•	•				
Pteracontiodus cryptodens					•		• •				
Semiacontiodus cornuformis							• •				
Tasmanognathus sp.							•				
				•							
Triangulodus cf. *T. brevibasis*						•	•				
Protopanderodus varicostatus							•				
Dapsilodus cf. *D. mutatus*							•				
Cornuodus longibasis				•	•		•				

Table 6.1. Age and Range of the Lower to Middle Ordovician conodonts from the Karmberg Limestone, Tasmania.

- Range of conodonts from samples obtained from The Gap, Florentine Valley. Tasmania.

Country			Acodus russoi	Acontiodus iowensis	Ancanthodus lineatus	Drepanodus parallelus	Drepanodus homocurvatus	Teridontus nakamurai	Oneotodus ?gracilis	Rossodus manitouensis	Drepanoistodus basiovalis	Oistodus lanceolatus	Scolopodus filosus	Variabiloconus variabilis	Glyptoconus quadriplicatus	Scolopodus krummi	Reutterodus andinus	Drepanodus arcuatus	Bergstroemognathus extensus
Argentina	San Juan Fm.		•								•	•				•	•	•	•
	La Silla Fm.								•	•								•	
	Gualcamayo Fm.										•	•							
	Niquivil Fm											•					•		
	Rio Sasso																•		
	Cuyania Terrane																•		
	Siberia				•						•								
	Russia																		
	Estonia																		
	Poland																		
Tasmania	Beaconsfield			•															
	Goliath Quarry																		
	Karmberg L/stone		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	Gordon L/stone																		
Australia	Burke River				•							•							
	Coolibah Fm.													•					
	Stokes Siltstone																		
	Canning Basin																		•
	Georgina Basin																		
	Mt. Arrowsmith																		
	Horn Valley S/stone																		
	Hensleigh Fm.																		•
	Mornington Pennin.																		•
	Hotham Group																		
N. Zealand	Mt. Patriarch			•															
	North China																		
	Hongbuayuan Fm.	South China		•							•							•	•
	Dawan Fm.																		•
	Huanghuachang Fm.																		•
	Daping																		
	Yaoxian Fm.	North China																	
	Fenfeng Fm.																		
	Dumugol Fm.	Korea									•								
	Southern uplands: Sc.																		
Malaysia	Langkawi Islands										•								
Thailand	Thung Song Fm.																		
	Central Sweden		•								•			•				•	

Country			Protopanderodus elongatus	Juanognathodus variabilis	Appalachignathus sp.	Oepikodus evae	Oistodus hunickeni	Protopanderodus cf. gradatus	Protopanderodus cf. P. leei	Jumudontus gananda	Aurilobodus sp.	Protopanderodus cf. P. primitus	Scalpellodus tersus	Scalpellodus cf. sp. S. tersus	Scolopodus rex	Paltodus sweeti	Oepikodus sp.	Oepikodus communis	Scandodus americanus
Argentina	San Juan Fm.		•	•		•	•	•		•					•	•		•	•
	La Silla Fm.							•							•			•	
	Gualcamayo Fm.																		
	Niquivil Fm																		
	Rio Sasso																		
	Cuyania Terrane																		
	Siberia																		
	Russia					•													
	Estonia					•													
	Poland																		
Tasmania	Beaconsfield														•				
	Goliath Quarry			•															
	Karmberg L/stone		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	Gordon L/stone			•				•											
Australia	Burke River																		
	Coolibah Fm.				•					•		•							
	Stokes Siltstone				•														
	Canning Basin																		
	Georgina Basin									•									
	Mt. Arrowsmith									•									
	Horn Valley S/stone					•				•		•							
	Hensleigh Fm.									•									
	Mornington Pennin.																		
	Hotham Group																		
N. Zealand	Mt. Patriarch																		
	North China				•														
	Hongbuayuan Fm.	South China	•	•				•											
	Dawan Fm.		•	•	•	•		•				•			•				
	Huanghuachang Fm.														•				
	Daping														•				
	Yaoxian Fm.	North China																	
	Fenfeng Fm.																		
	Dumugol Fm.	Korea							•			•	•		•				
	Southern uplands: Sc.																		
Malaysia	Langkawi Islands					•													
Thailand	Thung Song Fm.														•				
	Central Sweden					•						•							

Country			Polonodus sp.	Scandodus furnishi	Scolopodus floweri	Protopanderodus rectus	Juanognathodus jaanussoni	Stolodus cf. S. stola	Triangulodus larapintinensis	Drepanoistodus forceps	Aurilobodus leptosomatus	Pteracontiodus cryptodens	Semiacontiodus cornuformis	Tasmanognathus sp.	Erismodus gracilis	Triangulodus cf. T. brevibasis	Protopanderodus varicostatus	Dapsilodus cf. D. mutatus	Cornuodus longibasis
Argentina	San Juan Fm.		•	•	•		•	•		•		•				•	•		•
	La Silla Fm.		•		•														
	Gualcamayo Fm.		•									•							
	Niquivil Fm																		
	Rio Sasso																		
	Cuyania Terrane																		
	Siberia																		
	Russia																		
	Estonia																		
	Poland																		
Tasmania	Beaconsfield								•										
	Goliath Quarry																		
	Karmberg L/stone		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	Gordon L/stone									•				•	•				
Australia	Burke River				•														
	Coolibah Fm.								•		•					•			
	Stokes Siltstone																		•
	Canning Basin																		•
	Georgina Basin								•										
	Mt. Arrowsmith																		
	Horn Valley S/stone								•										
	Hensleigh Fm.																		
	Mornington Pennin.																		
	Hotham Group																		
N. Zealand	Mt. Patriarch																		
	North China										•			•		•		•	•
	Hongbuayuan Fm.	South China									•						•		•
	Dawan Fm.						•	•		•									
	Huanghuachang Fm.							•											
	Daping																		
	Yaoxian Fm.	North China												•					
	Fenfeng Fm.																		
	Dumugol Fm.	Korea																	
	Southern uplands: Sc.																		•
Malaysia	Langkawi Islands																		•
Thailand	Thung Song Fm.																		•
	Central Sweden							•		•						•			•

Table 6.2.a. The distribution of the genera and species of the conodont fauna from the Karmberg Limestone in other locations.

			Acodus russoi	Acontiodus iowensis	Ancanthodus lineatus	Drepanodus parallelus	Drepanodus homocurvatus	Teridontus nakamurai	Oneotodus ?gracilis	Rossodus manitouensis	Drepanoistodus basiovalis	Oistodus lanceolatus	Scolopodus filosus	Variabiloconus variabilis	Glyptoconus quadriplicatus	Scolopodus krummi	Reutterodus andinus	Drepanodus arcuatus	Bergstroemognathus extensus	Protopanderodus elongatus	Juanognathodus variabilis	Appalachignathus sp.	Oepikodus evae	Oistodus hunickeri	Protopanderodus cf. gradatus	Protopanderodus cf. P. leei	Jumudontus gananda	Aurilobodus sp.	Protopanderodus cf. P. primitus	Scalpellodus tersus	Scalpellodus cf. sp.S. tersus	Scolopodus rex	Paltodus sweeti	Oepikodus sp.	Oepikodus communis	Scandodus americanus	Polonodus sp.	Scandodus furnishi	Scolopodus flowerii	Protopanderodus rectus	Juanognathodus jaanussoni	Stolodus cf. S. stola	Triangulodus larapintinensis	Drepanoistodus forceps	Aurilobodus leptosomatus	Pteracontiodus cryptodens	Semiacontiodus cornuformis	Tasmanognathus sp.	Erismodus gracilis	Triangulodus cf. T. brevibasis	Protopanderodus varicostatus	Dapsilodus cf. D. mutatus	Scandodus brevibasis	Cornuodus longibasis
	Table Head	Newfoundland									•																																											
	Broken Skull Fm.	Selwyn Basin								•	•						•				•																																•	
	Kechika Basin										•																																													
	Survey Peak				•					•	•						•																																							
	Haywire Fm.										•																																												
	Alberta				•																														•									•										
	Cows Head Fm.			•						•							•	•	•		•						•								•	?	•							•		•								•
	Ville Guay	Quebec																	•																																			
	Levis Fm.	Quebec																																							•													
Canada	Ships Point																										•																											
	Eleanor Riv. Fm.																										•																											
	Arctic region.																																																					
	Miamichi Anticlin.	New Brunswick																	•																																			
	Tetagouche Group																																																					
	Camel Back Mt.																		•																																			
	Canadian Icefields																																																					
	Goat Head Group																																																					
	Road River Group																																																					
	El Paso	Texas	•		•							•	•				•				•		•		•	•									•				•	•	•													
	Hamberg klippe	Pennsylvania			•									•																																								
	Arkansas			•	•		•				•																								•											•								
	McKenzie Hill			•									•																																									
	March Fm.			•																																																		
	Burnham L/stone	Texas		•																																																		
	Marathon Fm.	Texas																	•																																			
USA	Nine Mile Shale	Nevada												•					•																	?•																		
	Styvesant Falls Fm.	N.Y.																	•																																			
	Cool Ck. Fm.	Oklahoma																																																				
	New York							•						•													•								•							•												
	Missouri Gulch	Colorado											•	•																																								
	Pratt Ferry Fm																																																					
	Highgate Gorge	Vermont																																																				
	Taconic Allochthon																																																					•

Table 6.2b. The distribution of the genera and species of the conodont fauna from the Karmberg Limestone in other locations.

			Sectic Intervals	Karmberg Limestone	Fauna	Main sediments
ORDOVICIAN	E. variabilis	Darriwilian	KARM 10		Conodonts, Ostracods, crinoid ossicles, sponge spicules, gastropods.	Impure limestone, nodules present, iron minerals, dolmitic grains.
			KARM 9		Conodonts, sponge spicules, brachiopods gastropods.	Impure limestone, some nodules, Micrite, minor pyrite, dolomitic grains, iron minerals.
	M. parva		KARM 8		Abundant conodonts, sponge spicules, gastropods, trilobite	Impure, nodular l/stone, some clay, an increase in dolomitic sediments.
	B. navis	Arenig	KARM 7		Conodonts, gastropods, sponge spicules, bryozoa.	Impure limestone, nodules, grains, tuff? iron minerals, dolomitic grains.
	O. evae		KARM 6		Conodonts, sponge spicules, gastropods, crinoid ossicles;ostracods.	Impure, nodular limestone.
	P. elegans		KARM 5		Conodonts, crinoids, sponge spicules, brachiopods, gastropods	Minor clays, dolomite, iron minerals. Nodular, inpure limestone.
			KARM 4		Conodonts, gastropods, sponge spicules, ostracods	Impure nodular, limestone, some pyrite.
	O. elongatus	Tremadoc	KARM 3		Few conodonts, gastropod moulds	Impure nodular, limestone, schist grains(?), some pyrite and dolomitic grains.
	P. proteus		KARM 2		Abundant sponge spicules crinoid ossicles, trilobite pygidium, gastropods.	High clay content, Some l/stone nodules, dolomite grains, quartz grains.
	P. deltifer / C. angulatus		KARM 1		Conodonts, gastropods, sponge spicules.	Very high clay content.
			Florentine Valley Fm.			

Table 6.3. A stratigraphic column of the Karmberg Limestone at the Gap showing the sample sites, the main fauna encountered, the lithology and a tentative conodont zonation based upon the sites which produced the most conodont specimens.

In some sections too few conodonts were recovered to accurately establish conodont zones within the Karmberg Limestone.
Estimated thickness 40m

of 5.0. Most of the elements are incomplete and this has tended to obscure some of the taxonomic features that are relied upon for an accurate diagnosis of the species. The CAI values are tabled in Chapter 9 (Table 9.5. herein).

Palaeobiogeographic distribution of the Conodonts (Lower to Middle Ordovician) from the Karmberg Limestone, Florentine Valley, Tasmania.

Conodont Palaeoecology.

This study covers only an investigation of the conodont fauna recovered from some 10–30 m of the basal region of the Karmberg Limestone just above the boundary of the Florentine Valley Formation. The age of the conodont species recovered is shown in Table 6.1.

Table 6.2a and 6.2b shows the distribution of the Tasmanian Lower Ordovician conodonts obtained from the Karmberg limestone within the Florentine Valley and the countries forming Gondwana during the Lower to Middle Ordovician. Tables 6.2a and 6.2b also show the distribution of the species through North American and some of the European countries during the Lower to Middle Ordovician. The Tasmania conodont fauna from the Karmberg Limestone have many species in common with the North American species from the El Paso Formation Texas (Lower Ordovician, Tremadoc).

Tables 6.2a and 6.2b show that the more common species inhabited Argentina, Tasmania, the Stokes Siltstone, the Horn Valley within the Amadeus Basin, and the Coolibah Basin within the Georgina Basin. Conodont species from Argentina, South China and Korea also show a close correlation with Lower Ordovician conodonts from Australia and Tasmania. The closeness of these land masses to each other during the Lower to Middle Ordovician permitted the different species to migrate from west to east using known marine currents which existed at that time. Conodont species were also able to move into the larger basin areas of western and Central Australia through the Larapintine Sea way before it closed.

A comparison of the North American Mid continent conodont faunas of ETHINGTON & CLARK (1971) and the fauna of SERPAGLI (1974) from Argentina are shown in Table 6.7. A close correlation with the Karmberg faunas is indicated.

Work on Early Ordovician nautiloids in Australia and Tasmania indicate that some species of these organisms exist within the Canning, Amadeus and Georgina Basins on the Australian mainland (STAIT & BURRETT 1987).

Environments of the Karmberg Limestone conodonts.

Shelf and Shelf edge.

Oepikodus communis, Drepanoistodus concavus, Drepanoistodus forceps and *Drepanodus arcuatus* are associated with conodont fauna which are common on limestone shelves or shelf edges in the Cows Head Formation of Newfoundland. POHLER (1994). *Bergstroemognathus extensus* and *Oepikodus evae* were recovered from quieter, shelf edge environments. Although few of these elements were recovered from the Karmberg Limestones the association of these conodonts species indicates that a similar environment may have existed for these species in Tasmania.

Lower slopes.

POHLER (1994) also recovered common species including *Drepanodus arcuatus, Glyptoconus quadraplicatus* and *Drepanodus* sp. aff. *D. concavus* from the lower slopes environments of the Cows Head Formation (POHLER 1994). Conodont species such as *D. arcuatus* and *Reutterodus andinus* tended to frequent quieter environments

Age of the Tasmanian Lower Ordovician conodonts.

Lower Ordovician conodonts from the Karmberg Limestone from reworked sediments near the contact with the Florentine Valley Formation show an age range from the *C. angulatus* Zone to the *E. variabilis* Zone. Other anomalies includes specimens of *D.* cf. *D. mutatus and C. longibasis* that have a range extending into the upper Ordovician. Table 6.5 shows the possible Assemblage Zones for the Lower Ordovician in Tasmania.

HIBBARD et al., (1976) reported a conodont fauna including *Drepanodus arcuatus, Oepikodus* sp. cf. *P.* (*O.*) *evae, Protopanderodus rectus*, *Scolopodus* sp. and *Scandodus* sp. from the Dunnage Mélange of north–central Newfoundland. These species are found in the conodont fauna reported from the Karmberg Limestone of Tasmania.

Systematic Palaeontology.

All conodont elements were obtained from the lower part of the Karmberg Limestone at The Gap on the Florentine Road, Tasmania.

Phylum: Chordata BATESON, 1886
Class: Conodonta EICHENBERG 1930
sensu CLARK 1981

Genus *Acanthodus* FURNISH 1938.

Type species: *Acanthodus unicinatus* FURNISH 1938.

Acanthodus lineatus FURNISH 1938
Plate 6.11, fig. 3.

Synonymy:

1938 *Drepanodus lineatus* FURNISH; p. 328, Pl. 41, figs. 33, 34, Text–fig. 1H.
1958 *Acanthodus* sp. A., HASS; In: SANDO, p. 841–842, Pl. 2, fig. 20.
1971 *Acanthodus costatus* (Jun. syn.), JONES; p. 42-43, Pl. 1, figs 4a, b.
1971 *Acanthodus costatus* (Jun. syn.), DRUCE & JONES; p. 54–55, Pl. 5, figs. 1a–5c, Text–fig. 19a.
1982 *Acanthodus lineatus* (FURNISH); REPETSKI, p. 10, Pl. 1, figs. 1, 3.
1996 *Acanthodus lineatus* (FURNISH); JI & BARNES, Fig. 11, 1–6.

Remarks:
The elements are very similar to the *e* elements in JI & BARNES (1996, figs. 4, 5, 6) having the strongly recurved cusp and the flared basal region. The anterior edge of the elements is sharper due to the flattening of the anterior sides. REPETSKI (1982) noted the costae on the flattened anterior edge of the elements.

Age:
JI & BARNES (1996) recorded *Acanthodus lineatus* in fauna of equivalent age to the lower and middle parts of Fauna C of ETHINGTON & CLARK (1971) that is within the *Loxonodus bransoni* (*C. angulatus*) Conodont Assemblage Zone.

SEO et al., (1994) recorded their specimens of ?*Acanthodus lineatus* within the Upper Tremadoc ("*Acanthodus—Chosonodina—Loxodus* " Assemblage Zone) in Korea.

Specimens:
Sample KARM 4: One Sa (*e*) element.

Genus *Acontiodus* PANDER 1856
Type Species: *Acontiodus latus* PANDER 1856
emend. ULRICH & BASSLER 1926

Acontiodus iowensis FURNISH 1938
Plate 6.1, fig. 8.

Synonymy:

1938 *Acontiodus iowensis* FURNISH; p. 325–326, Pl. 42, figs. 16–17, Text–fig. 1L
1964 *Acontiodus iowensis* (FURNISH); ETHINGTON & CLARK, p. 687, Pl. 113, fig. 3.

1968 *Acontiodus iowensis* (FURNISH); MOUND, p. 407, Pl. 1, figs. 20–27.

1971 *Acontiodus iowensis* (FURNISH); JONES, in part, p. 64, Pl. 6, Fig. 3,
(non fig. 4 = *Acontiodus propinquus* Pl. 9, fig. 6

1971 ?*Scolopodus transitans* DRUCE & JONES; p. 95–96, Pl. 15, Figs. 10-11,
Text–Fig. 30G, H,

1971 ?*Scolopodus transitans* (DRUCE & JONES); JONES, p. 68, Pl. 6, figs. 8–11, Pl. 9,
fig. 6.

1971 *Acontiodus staufferi* (FURNISH); GREGGS & BOND, Pl. 1, figs. 1, 2.

1975 *Scolopodus* aff. *S. iowensis* (FURNISH); COOPER & DRUCE, p. 578, fig. 31.

1982 *Acontiodus iowensis* FURNISH; s.f. REPETSKI, p. 14. Pl. 4, figs. 1, 3.

1993 Element D, STAIT & DRUCE; p. 322, fig. 22, D.

Remarks:

Acontiodus iowensis FURNISH is very similar to the element illustrated in REPETSKI (1982, Pl. 4, fig. 1b). The element has an expanded sub oval base and the lateral costae are attached to the lateral basal margins. The posterior edge of the cusp is rounded and the sides of the posterior edge are almost parallel flaring outwards as it approaches the posterior basal margin.

Age:

MOUND (1968) recorded an age of within the Upper Tremadoc (upper *Chosondina herfurthi—Loxonodus bransoni* Assemblage Zone). This is equivalent to the *C. angulatus* Zonein in the Baltic Region. (REPETSKI 1982) reported *Acontiodus iowensis* from the El Paso Formation, Texas (Middle Tremadoc to Middle Arenig).

Acontiodus iowensis has been reported from the middle of the *Chosondina herfurthi—Acodus* Zone (Upper Tremadoc) in New Zealand (WRIGHT et al., 1994).

Specimens:

Sample KARM 7: One element.

Genus *Aphelognathus* BRANSON, MEHL & BRANSON 1951

Type Species: *Aphelognathus grandis* BRANSON, MEHL & BRANSON 1951

Aphelognathus sp. cf. *A. politis* HINDE 1879

Plate 6.19, fig.10.

Synonymy:

1995a LEHNERT (*cum syn,* 1933 to 1979).

1981 *Aphelognathus politus* (HINDE); SWEET In: ZIEGLER p. 41–43.

1981 *Aphelognathus politus* (HINDE); REPETSKI, figs. 77F, 77G.

1987 *Aphelognathus politus* (HINDE); AN, p, 124, 125, Pl. 28, figs. 8–10.

1988 *Aphelognathus politus* (HINDE); NOWLAN et al., p. 11, 12.

1990 *Aphelognathus politus* (HINDE); POHLER & ORCHARD Pl. 6, figs. 4–7.

1995a *Aphelognathus politus* (HINDE); LEHNERT, p. 73, Pl. 19, figs. 2–9.

Remarks:
The damaged ozarkodiniform element is similar to the Pb elements in LEHNERT (1995b, Pl. 19, fig. 2,3). The Karmberg element appears to have a raised main denticle towards the anterior end and may be an element of ?*Aphelognathus* sp. cf. *A. politius.*

Age:
Equivalent age to the Niquivil Section IV (*Oepikodus evae* Zone) in Argentina (LEHNERT 1995a).

Specimen:
Sample KARM 2. One element

Genus *Appalachignathus* BERGSTRÖM, CARNES, ETHINGTON. VOTAW & WIGLEY 1974

Type Species: *Appalachignathus delicatus* BERGSTRÖM, CARNES, ETHINGTON, VOTAW & WIGLEY 1974.

Appalachignathus sp.?

Plate 6.1, fig. 7.

Remarks:
The S element is palmate and curved,. The basal cavity is very shallow and almost as wide as the element. The lateral sides of the cusp are denticulated but the lengths of the denticles compared to their width cannot be determined from the specimens.

Age:
The species was recovered from within a lower to middle Arenig fauna in the Coolibah Formation of central Australia (STAIT & DRUCE 1994).

Specimen:
Sample KARM 10. Two specimens.

Genus *Aurilobodus* XIANG & ZHANG 1983

Type species: *Tricladiodus aurilobus* LEE 1975

Aurilobodus ?leptosomatus AN 1983

Plate 6.1, figs. 3, 4, 6.

Synonymy:

1983 *Aurilobodus leptosomatus* AN; AN et al., p. 72–73, figs. 14–17, Pl. 22, fig. 1.

1988 *Juanognathodus leptosomatus* (AN); WATSON, p. 116, Pl. 1, figs. 1–3, 6,

1993 *Aurilobodus ? leptosomatus* AN; p. 302, fig. 17A–C.

Remarks:

The elements are morphologically similar to the species *Aurilobodus ?leptosomatus* AN (STAIT & DRUCE (1993, Fig. 17, F).

This species differs to other species of *Aurilobodus* by having the alae on the lateral wing like costae which are also more regular in shape. The basal cavity is rounded. The serrations on the lateral alae are not regular and the specimens are therefore not assigned to elements of *Aurilobodus serratus.*

The element in Plate 6.1, fig. 5 is classified as a possible species of *Aurilobodus leptosomatus.* The posterior view is not unlike the element of *Ansella nevadensis* ETHINGTON & SCHUMACHER, recorded by MCCRACKEN (1991, Plate 23, fig. 26), (In: ORCHARD & MCCRACKEN 1991).

Age:

The age ranges from Middle to Late Arenig for the specimen from the Coolibah Formation, Central Australia (STAIT & DRUCE (1993).

Specimens:

Sample KARM 6: One specimen of *Aurilobodus ?leptosomatus.*

Sample KARM 7: One specimen of *Aurilobodus ?leptosomatus.*

Sample KARM 8: One specimen of *Aurilobodus ?leptosomatus.*

Genus *Bergstroemognathus* SERPAGLI 1974

Type species: *Oistodus extensus* GRAVES & ELLISON 1941.

Bergstroemognathus extensus (GRAVES & ELLISON 1941).

Plate 6.1, figs. ?9, 10, 11.

Synonymy:

1941 *Oistodus extensus* GRAVES & ELLISON; p. 13, Pl. 1, figs. 16, 28, Pl. 1, fig. 20?

1969? *Falodus* cf. *F. extensus* (GRAVES & ELLISON); BRADSHAW, p. 1151, Pl. 135, fig. 15.

1974 *Bergstroemognathus extensus* (GRAVES & ELLISON); SERPAGLI, p. 40, Pl. 9, figs. 1a–8a, Pl. 21, figs. 1–7.

1976 *Bergstroemognathus* cf. *B. extensus* (GRAVES & ELLISON); LANDING, p. 40, Pl. 9, figs. 1–6, 9, 10.

1987 *Bergstroemognathus extensus* (GRAVES & ELLISON); AN, p. 131–132, Pl. 23, figs. 8, 9, 11, 13-15, 17, 21, Pl. 29, Fig. 6, (*cum syn.*)

1987 *Bergstroemognathus extensus* (GRAVES & ELLISON); HÜNICKEN & SARMIENTO, p. 621–622, Pl. 1, figs. 1–5.

1988 *Bergstroemognathus extensus* (GRAVES & ELLISON); STOUGE & BAGNOLI, p. 113, Pl. 1, figs 6–13, (*cum syn.*)

1990 *Bergstroemognathus extensus* (GRAVES & ELLISON); SARMIENTO, Pl. 3, figs. 1, 3, 4, 6.

1990 *Bergstroemognathus extensus* (GRAVES & ELLISON); AN, Pl. 8, figs. 6–8.

1990 *Bergstroemognathus extensus* (GRAVES & ELLISON); POHLER & ORCHARD, Pl. 3, fig. 14.

1991 *Bergstroemognathus extensus* (GRAVES & ELLISON); SMITH, p. 21, 22, Tab. 13a–13g.

1993 *Bergstroemognathus extensus* (GRAVES & ELLISON); LEHNERT, Pl. 1, figs, 4, 6, 9.

1994 *Bergstroemognathus extensus* (GRAVES & ELLISON); POHLER, Pl. 1, figs. 19–22.

1995 *Bergstroemognathus extensus* (GRAVES & ELLISON); WANG & BERGSTRÖM, Pl. 6, figs. 6–8, 10.

1995b *Bergstroemognathus extensus* (GRAVES & ELLISON); LEHNERT, p. 75, Pl. 5, figs. 20, 21, Pl. 20–A, fig. 6, Pl. 20–B, fig. 2.

?1998 *Bergstroemognathus extensus* (GRAVES & ELLISON); LEHNERT et al., p. 55, Pl. 2, fig. 2.

1998 *Bergstroemognathus extensus* (GRAVES & ELLISON); ALBANESI, p. 177-178, Pl. 12, figs. 26–32, Text–fig. 33.

1999 *Bergstroemognathus extensus* (GRAVES & ELLISON); PERCIVAL et al., p. 11, Fig. 8, figs. 8.1–8.3.

2001 *Bergstroemognathus extensus* (GRAVES & ELLISON); ZHEN et al., p. 195–199, Figs. 6.1–6.26. (*syn* to 1993).

2003 *Bergstroemognathus extensus* (GRAVES & ELLISON); PYLE & BARNES, p. 149, fig. 3, Fig. 11.10.

Remarks:

Bergstroemognathus extensus SERPAGLI is a multielement species containing Pa, Pb, Sa (trichonodelliform), Sb (prioniodiform), Sc, and M elements. The two Pb elements are illustrated in Plate 6.1, figs. 10–11. The cusp is long recurved slightly inwards and is multidenticulate. The denticles are reclined and appear to be fused at the base but become separated towards the apical ends. The denticles are very similar to the denticles on the anterior side of the main cusp of the element illustrated in SERPAGLI (1974, Plate 9, fig. 1a) and in ZHEN et al., (2001, fig. 5, and Fig. 5).

The Pa? fragment shown Plate 1, fig. 9 is tentatively diagnosed as a part of an element of *B. ?extensus*. The denticles are upright and are very similar to the posterior portion of the sketch of the Pa element *B. ?extensus* (In: ZHEN et al., 2001, fig. 5, and Fig. 8, diag.9). The denticles are also not unlike the anterior denticles of *Fahraeusodus marathonensis* BRADSHAW (ALBANESI 1998b, Pl. 4, fig.19b). The Tasmanian specimens are not as reclined as the specimen in AN et al., (1985, Pl. 7, fig. 2).

Age:

Bergstroemognathus extensus reported from Fauna A of the San Juan Formation of Argentina (SERPAGLI 1974) ranged within the *P. elegans* Zone, possibly extending into the *P. evae* Conodont Zone. *Bergstroemognathus extensus* ranged from the middle to later Ordovician *O. evae* to the *P. elegans* Assemblage Zone. LEHNERT (1995a) reported the species may range into the Middle Ordovician (*B. navis* to *T. triangularis* Assemblage Zone) in Argentina.

In North America *Bergstroemognathus extensus* has been reported from basal *O. evae—O. communis* Assemblage Zone in the Marathon Basin of Texas (ETHINGTON et al., 1995).

In southern China the species occurs with the lower limit of the *Prioniodus proteus* to the upper limit of the *Prioniodus elegans* Assemblage Zone (Lower Arenig). NI (1981), AN (1982), ZENG (1983), and WANG, et al., (1983). AN et al., (1985), recorded a range from the *B. navis, O. evae, J. variabilis* and *B. triangulodus* Zones. The species is common from the *O. evae* to *B. navis* Assemblage Zone (DING et al., In: WANG et al., 1996), and AN & ZHENG (1990).

Bergstroemognathus extensus has been recorded from strata of Bendigonian age from the Hensleigh Siltstone, N.S.W., Australia by ZHEN et al., (in press) and PERCIVAL et al., (1999) and from the Canning Basin by ZHEN et al., (2001). *Bergstroemognathus extensus* from the Mornington Peninsula, Victoria is Chewtonian (Lower Middle Arenig) in age. Within the Hotham Group, Victoria, a Bendigonian–Chewtonian age has been suggested (STEWART & FERGUSSON 1988, ZHEN et al., (2001)

The two Pb specimens reported from Tasmania (this study) are considered to be located from within the *O. evae* to the *P. elegans* Assemblage Zones.

PYLE & BARNES (2003) reported *B. extensus* from the *B. extensus* Zone (=Middle to Upper *O. communis* Zone) from the Kechika, Skoki and Beaverfoot Formations, British Columbia, Canada.

Specimens:
Three elements were obtained from the Karmberg Limestone.
Sample KARM 6?: Fragment of an Sa element.
Sample KARM 1: Pb element.
Sample KARM 8: Pb element.

Genus *Cornuodus* FÅHRÆUS 1966

Types Species: *Cornuodus erectus* FÅHRÆUS 1966
(= *Drepanodus longibasis* LINDSTRÖM 1955)

Cornuodus longibasis LINDSTRÖM 1955
Plate 6.2, figs. 1–11, ?12.

Synonymy:

1955 *Drepanodus longibasis* n. sp. LINDSTRÖM: p. 564, Pl. 3, fig. 31.
1955a *Drepanodus longibasis* LINDSTRÖM; p. 564, Pl. 3, fig. 341.
1963 *Cornuodus longibasis* SERGEEVA; Tab. 1.
1965 *Cornuodus longbasis* ETHINGTON & CLARK; p. 190.
1966 *Cornuodus erectus* n. sp. FÅHRAEUS; p. 20, Pl. 2, fig. 8a–b, text–fig. 2B.
1978 *Cornuodus longibasis* (LINDSTRÖM); LÖFGREN, Pl. 4, figs. 36, p. 38–42, text–fig. 25A–C (With additional synonymy).
1978 *Cornuodus bergstroemi* LÖFGREN; Pl. 2, fig. 37, text–fig, 25D.
1984 *Cornuodus longibasis* (LINDSTRÖM); STOUGE, p. 62, Pl. 8, figs. 1–8.
1988 *Cornuodus longibasis* (LINDSTRÖM); STOUGE & BAGNOLI., p. 114, Pl. 1, figs. 20–21.
1990 *Cornuodus longibasis* (LINDSTRÖM); STOUGE & BAGNOLI, p. 14, Pl. 3, figs. 3–7.
1994a *Cornuodus longibasis* (LINDSTRÖM); DZIK, p. 61, Pl. 11, figs. 9–13, text–fig. 4a. (non sp. element).

1995 *Cornuodus longibasis* (LINDSTRÖM); WANG & BERGSTRÖM, Pl. 7, fig. 2.

1995a *Cornuodus longibasis* (LINDSTRÖM); ALBANESI et al., Pl. 3, fig. 9.

1995a *Cornuodus longibasis* (LINDSTRÖM); LEHNERT, p. 73–74, Pl. 15, figs. 8, 9, 11.

1995 *Cornuodus longibasis* (LINDSTRÖM); ALBANESI, et al., Pl. 3, fig. 9.

1996 *Cornuodus longibasis* (LINDSTRÖM); LÖFGREN, fig. 5AE.

1997 *Cornuodus longibasis* (LINDSTRÖM); ARMSTRONG, p. 785 (pars.) Pl. 4, figs. 11–22, non–fig. 12, ? Pl. 4, figs. 21–22. Text–fig. 6.

1998b *Cornuodus longibasis* (LINDSTRÖM); ALBANESI, p. 118, Pl. 2, figs. 30–33.

1998 *Cornuodus longibasis* (LINDSTRÖM); ZHANG, p. 57, Pl. 1, figs. 15–19.

1999 *Cornuodus longibasis* (LINDSTRÖM); LÖFGREN, p. 180–184, Pl. 1, figs. 1–21, Pl. 2, figs. 1–13, Pl. 3, figs. 1–20.

2001 *Cornuodus longibasis* (LINDSTRÖM); RASMUSSEN, p. 50–51, Pl. 3, figs. 7, 8.

2001 *Cornuodus longibasis* (LINDSTRÖM); PYLE & BARNES, p. 149, fig. 3,

Remarks:

All specimens obtained from the Karmberg Limestone within the Florentine Valley of Tasmania are classified as S elements. The cusps of the element are recurved and laterally compressed. Lateral costae are located towards the posterior edge of the cusp. The base is short and wider at the basal end and laterally compressed. The basal cavity is deep and extends to almost the mid point of the cusp. The apex of the basal cavity is slightly behind the mid line of the cusp.

Using the classification suggested in LÖFGREN (1999, Pl. 1) and the sketched elements in LÖFGREN (op. cit., Pl. 2, figs. 6, 8) have been classified as S elements.

Age:

Cornuodus longibasis is a long ranging Ordovician species ranging from the Tremadoc to the Ashgill. In South China WANG & BERGSTRÖM (1999) gave an age of lower *P. originalis* Zone. Specimens from the Jianyangping Section had an extended range of uppermost part of the Earliest Darriwilian (*Baltoniodus norrlandicus—M. parva* Assemblage Zone.

PYLE & BARNES (2003) reported *B. extensus* from the *A. kechikaensis* Zone (=uppermost *P. gracilis* to lowermost *P. elegans* Zone) from the Kechika Formation, British Columbia , Canada.

Specimens:

Sample KARM 7: One Pb element.

Sample KARM 5: One Sa element.

Sample KARM 6: One Sa element.
Sample KARM 5: One Sb element.
Sample KARM 2: One Sb element.
Sample KARM 9: One Sb element.
Sample KARM 8: One Sc element.
Sample KARM 1: Two Sd element.
Sample KARM 8: One Sd element.
Sample KARM 4: One S? element.
Sample KARM 6: One S? element.

Genus *Dapsilodus* COOPER 1976

Type Species: *Distacodus obliquicostatus* BRANSON & MEHL 1933

Dapsilodus mutatus BRANSON & MEHL 1933
Plate 6.1, fig. 12.

Synonymy:

?1933 *Belodus ? mutatus* BRANSON & MEHL, p. 126, Pl. 10, fig. 17.
?1980 *Dapsilodus mutatus* (BRANSON & MEHL); ORCHARD p. 20, Pl. 5, fig. 6, 15, 16, 21 (*cum syn.*)
1990a *Dapsilodus mutatus* (BRANSON & MEHL); BERGSTRÖM, Pl. 2, figs. 1–2, Pl. 3, fig. 14, Pl. 4, fig. 8.
1999 *Dapsilodus mutatus* (BRANSON & MEHL); FERRETTI & SERPAGLI, p. 230, Pl. 3, figs. 20–23. (*cum syn.* 1998).

Remarks:

Only one element of *Dapsilodus mutatus* BRANSON & MEHL was recovered from the Karmberg Limestones. The morphology is similar to the element in FERRETTI & SERPAGLI (1999, Pl. 1, fig. 22) from Sardinia. The element is a broad element and does not possess the "chevrons" on the antero aboral region of the elements described from England and Wales by ALDRIDGE (1982). The anterior basal edge of the element is sharp. This feature is very similar to the element of *Besselodus borealis* n. sp. (MCCRACKEN & NOWLAN (1989, In : NOWLAN et al., 1988, Plate 2, Fig. 1).

Age:

Dapsilodus mutatus has been recovered from the Middle to Upper Ordovician in Europe, Libya, North America and China and Sardinia (FERRETTI & SERPAGLI 1999). *Dapsilodus mutatus* has been recorded from the *Amorphognathus tvaerensis* to the *A. ordovicicus* Zone in Scotland (TROTTER & WEBBY 1994).

Specimen:
Sample KARM 8: One Acodontiform (Sc) element.

Genus *Diaphorodus* KENNEDY, 1980
Type Species: *Acodus delicatus* BRANSON & MEHL

Diaphorodus russoi SERPAGLI 1974
Plate 3.19, figs. 5–7.

Synonymy:

1974a *Acodus ? russoi* SERPAGLI; p. 35–37, Pl. 8, figs. 1–5, Pl. 20, figs. 7, 8, (*syn*).
1982 *Acodus ? russoi* (SERPAGLI); REPETSKI, p. 13, Pl. 3, figs. 1–5.
1983 *Acodus ? russoi* (SERPAGLI); ZENG et al., Pl. 11, figs. 7, 8, 16.
1987 *Acodus ? russoi* (SERPAGLI); AN, p. 119, figs. 7, 8, 16.
1990 *Acodus ? russoi* (SERPAGLI); SARMIENTO, Pl. 2, fig. 11.
1991 *Diaphorodus russoi* (SERPAGLI); STAIT & BARNES, Tab. 3b.
1991 *Diaphorodus russoi* (SERPAGLI); ALBANESI, p.66, Pl. 4, figs. 7a–10b.
1991 *Diaphorodus russoi* (SERPAGLI); SMITH, p. 26, figs.16f, g.
1991 *Diaphorodus russoi* (SERPAGLI); LEHNERT, Pl. 1, fig. 10.
1994 *Diaphorodus russoi* (SERPAGLI); LEHNERT, p. 81-82, Pl. 5, fig 23.
1998b *Diaphorodus russoi* (SERPAGLI); ALBANESI, p. 147-148, Pl. 4, figs. 11-15, Text-fig. 20.
2002 *Diaphorodus russoi* (SERPAGLI) PYLE & BARNES, p.

Remarks:
The element from the Karmberg Limestone is very similar to the belodiform element in SERPAGLI (1974, text–fig. 5 and Plate 8, fig. 2a). The base of the element has three processes connected by thin walls which surround the basal cavity. The basal cavity is more open and the posterior process arches downward.

Age:
The species has been described by LINDSTRÖM (1955) and as *Oepikodus* n. sp. by BARNES & TUKE (1970). It was recorded as *Acodus*? *russoi* within the *O. evae* Assemblage Zone in Argentina by SERPAGLI (1974) and within the ?*O. evae* Zone in the El Paso Formation (REPETSKI 1982).

PYLE & BARNES (2002) recorded *Diaphorodus russoi* from the Lower Ordovician Road River Group of British Columbia, Canada.

In Argentina SERPAGLI (1974) recorded *Diaphorodus russoi* within his Fauna B (*O. evae* Assemblage Zone). In a later paper ALBANESI (1998b) recorded *Diaphorodus russoi* SERPAGLI from the Lower-Middle Arenig (*P. elegans* to *T. laevis* Zone and the *P. proteus* (*O. elongatus* —*A. delatatus*) Subzone.

Specimen:
Sample KARM 2: One Sa element.
Sample KARM 4: One Sa element.

Genus *Drepanodus* PANDER 1856

Type Species: *Drepanodus arcuatus* PANDER 1856

Drepanodus homocurvatus LINDSTRÖM 1955
Plate 6.3, figs. 8–10.

Synonymy:

1933 *Oistodus curvatus* BRANSON & MEHL p. 110–111, Pl. 9, figs. 4, 10, 12. (non *D. curvatus* STAUFFER 1932).

1955 *Drepanodus homcurvatus* LINDSTRÖM; p. 563, Pl. 2, figs. 23–24, 39.

1967 *Drepanodus homcurvatus* (LINDSTRÖM); LONGWELL & MOUND, p. 408–409, Pl. 1.

1968 *Drepanodus homcurvatus* (LINDSTRÖM); MOUND; p. 411, Pl. 2, Figs. 20–27.

Remarks:
The elements from the Karmberg Limestone, Tasmania are morphologically similar to the elements of *Drepanodus homocurvatus* LINDSTRÖM recorded by MOUND (1968, Plate 2, figs. 20–27) from the Arbuckle Mountains, Oklahoma.

Age:
D. homocurvatus is not considered to be of any biostratigraphic significance (MOUND1968). The species ranged from the Early to the Late Ordovician in the U.S.A.

Specimens:
Only three specimens were recovered from the Karmberg Limestone.
Sample KARM 1: One S element.
Sample KARM 5: One S element.
Sample KARM 6: One S element.

Drepanodus parallelus BRANSON & MEHL 1933
Plate 6.3, figs. 11–12.

Synonymy:

1933 *Drepanodus parallelus* BRANSON & MEHL; p. 59, Pl. 4, fig. 17.

1933 *Drepanodus arcuatus* BRANSON & MEHL; p. 58, Pl. 4, figs. 7, 8, 13, 16.

1971 *Drepanodus parallelus* (BRANSON & MEHL); JONES, p. 52–53, Pl. 8, figs. 5a–c, (*Syn.* to 1971).

1975a *Drepanodus parallelus* (BRANSON & MEHL); LEE, p. 85–86, Pl. 1, fig. 16, Text–fig. 3–M.

1975 *Drepanodus parallelus* (BRANSON & MEHL); ABAIMOVA, p. 63–64, Pl. 6, Text–fig. 7–6, 40.

1977 *Drepanodus parallelus* (BRANSON & MEHL); REPETSKI & ETHINGTON, p. 95, 97.

1982 *Drepanodus parallelus* (BRANSON & MEHL); REPETSKI, p. 21, Pl. 6, figs. 9, 10.

Remarks:
REPETSKI (1982) considered *D. arcuatus* LINDSTRÖM and *D. parallelus* BRANSON & MEHL to be conspecific. The elements from the Karmberg Limestone are therefore classified by form taxonomy. Elements of *D. arcuatus* tend to have concave basal rims on the lateral surfaces which turn in towards the basal cavity (LEHNERT 1995a, Plate 3, figs. 15 and 16).

Age:
Drepanodus parallelus from the Lower Ordovician of the Cool Creek Formation, Arbuckle Mountains, Oklahoma and the El Paso Formation, Texas ranged through the Early Arenig to Early Darriwilian (*A.?deltatus* to *P. proteus* Assemblage Zone) (REPETSKI 1982).

ALBANESI (1998b) suggested the range of the species may extend to the *E. variabilis* Assemblage Zone in Argentina.

Specimens:
Sample KARM 2: One Sd element.
Sample KARM 6: One Sa element.

Genus *Drepanoistodus* LINDSTRÖM 1971

Type Species: *Oistodus forceps* LINDSTRÖM 1955

Drepanoistodus basiovalis SERGEEVA 1963

Plate 6.4, fig. 10, Plate 7.20, fig. 6.

Synonymy:

1963 *Oistodus basiovalis* SERGEEVA; p. 96, Pl. 7, figs. 6–7, Text–fig. 3.

1978 *Drepanoistodus basiovalis* (SERGEEVA); TIPNIS et al., Pl. 9. fig. 21.

1981 *Drepanoistodus basiovalis* (SERGEEVA); NOWLAN, p. 11, Pl. 3, figs. 20–22.

1984 *Drepanoistodus basiovalis* (SERGEEVA); STOUGE, p. 53, Pl. 3, figs 18–20.(*cum syn.*)

1990 *Drepanoistodus basiovalis* (SERGEEVA); STOUGE & BAGNOLI p. 15, Pl. 5, figs. 18–24, (*cum syn.*).

1998b *Drepanoistodus basiovalis* (SERGEEVA); ALBANESI, p. 135, Pl. 3, figs. 15–18. (*cum syn.* to 1996).

1998b *Drepanoistodus basiovalis* (SERGEEVA); ZHANG, p. 61–62, Pl. 5, figs. 5–12.

1998b *Drepanoistodus basiovalis* (SERGEEVA); RASMUSSEN, p. 71–72, Pl. 5, fig. 9.

Remarks:

The damaged element illustrated in Plate 4, fig. 8 is a drepanodiform (Sd) element. It has many of the features damaged that would assist in an accurate identification of the element. It is very similar to the element illustrated in BARNES et al., (1991, Pl. 3, fig. 15). It has a stout cusp and a broad, shallow basal cavity. The basal cavity is flattened and convex on the lateral faces. The anterior edge is sharp but only a fragment of the extended basal corner is visible.

The element in Plate 20, Fig. 6 is classified as an element of *Drepanoistodus basiovalis* SERGEEVA. The damaged cusp is geniculate in form and shows the typical oistodiform (M) flexure. The basal margins are downward flaring and the basal cavity is laterally expanded. The anterior and the posterior margins are sharp. The sharp costae at the anterior end of the element is missing.

Age:

D. basiovalis has been recorded from the Lower to Middle Ordovician (Early Tremadoc to the Late Arenig) in Korea (SEO et al., 1994).

D. basiovalis from the Broken Skull Formation of the Central Selwyn Basin of Canada has been found in association with a conodont fauna which are typically within the *"Scolopodus" quadratus—O. evae* Assemblage Zone. Elements recorded from the Kechika Basin of Canada were typically Late Arenig (post *O. evae* Zone) to Middle Darriwilian.

In Argentina ALBANESI (1998b) recorded *D. basiovalis* in Late Arenig to the Middle Darriwilian sediments (*B. navis* to the *E. variabilis* Assemblage Zone).

Specimen:
Two specimens were recovered from the Karmberg Limestone.
Sample KARM 2: One S element.
Sample KARM 4: One M element.

Drepanoistodus forceps LINDSTRÖM 1955
Plate 6.3, Figs, 1, 2, 4–7, Plate 6.4, Figs. 1, ?2, 3–7, ?9, ?11. Plate 6.5, figs. 1, ?2, 3, 4.

Synonymy:

1941 ?*Oistodus fornicaulus* GRAVES & ELLISON; p. 4, figs. 15, 17? Pl. 2, figs. 15, 18.
1955a *Oistodus forceps* LINDSTRÖM, p. 574, Pl. 4, figs. 9–13, Text–fig. 3M

1978 *Drepanoistodus forceps* (LINDSTRÖM); FÅHRHÆUS & NOWLAN, p. 459, Pl. 1, figs. 22, 23, 25, (non 24).
1984 *Drepanoistodus forceps* (LINDSTRÖM); STOUGE, p. 53, 54, Pl. 3. figs. 24, 25.
1988 *Drepanoistodus forceps* (LINDSTRÖM); BERGSTRÖM, Pl. 1, figs. 6, 7, (non 8), 9, 10.
1987 *Drepanoistodus forceps* (LINDSTRÖM); AN, p. 147, Pl. 15, fig. 26.
1990 *Drepanoistodus forceps* (LINDSTRÖM); STOUGE & BAGNOLI, Pl. 16, 17, Pl. 5, figs. 6–9, (In detail in Synonymy).
1995a *Drepanoistodus forceps* (LINDSTRÖM); LEHNERT, p. 84, Pl. 3, fig. 20, Pl. 6, fig. 2.
1998b *Drepanoistodus forceps* (LINDSTRÖM); ALBANESI, p. 136, Pl. 3, figs. 19–22. (*cum syn.* to 1996).

Remarks:
The elements from Tasmania are very similar to elements of *Drepanoistodus forceps* reported from Argentina and the Baltic Regions.

Age:
LEHNERT(1995a) reported *Drepanoistodus forceps* from within the *E. variabilis* Conodont Zone in Argentina. ALBANESI (1998b) recorded the species from Early to the Late Arenig (*P. elegans, O. evae, O. intermedius, T. laevis, B. navis* and *M. parva* Assemblage Zones) from the San Juan Formation, Argentina.

Specimens:
Sample KARM 7: One Sa element.
Sample KARM 2: One Sc element.
Sample KARM 5: Two Sc elements.
Sample KARM 6: Three Sc elements.

Sample KARM 8: Three Sc elements.
Sample KARM 4: One ?Sc element.
Sample KARM 8: One ?Sc element.
Sample KARM 4: One Sd element.
Sample KARM 3. One Sd element.
Sample KARM 1: One Sd element.
Sample KARM 7: One P? element.

Genus *Erismodus* BRANSON & MEHL 1933

Type Species: *Erismodus typus* BRANSON & MEHL 1933.

Erismodus gracilis BRANSON & MEHL 1933
Plate 6.3, figs. 12, 13.

Synonymy:

1967 *Erismodus gracilis* (BRANSON & MEHL); ANDREWS, p. 894, Pl. 112, fig. 19.
1995a *Erismodus* sp. LEHNERT; p. 87, fig. 12,
1998b *Erismodus* sp. ALBANESI; p. 175–176, Pl. 16. fig. 15.

Remarks:

The elements in Plate 6.3. figs 12, 13 appear to be the main cusps of a species of *Erismodus* BRANSON & MEHL. The cusp illustrated in Plate 6.3. fig14 is similar to the element illustrated in LEHNERT (1995a, Pl. 15 fig. 1). The cusp is reclined, and slender.

Age:

The species has been reported from limestone of Blackriveran age in Tasmania by BURRETT (1978, unpub). The species has also been recorded in the North American Fauna 7. (*P. variabilis* to the top of the *P. gerdae* Assemblage Zone. *Erismodus* sp. has been recorded from the *A. tvaerensis* Zone in Argentina (ALBANESI 1998b) and from the Las–Aguaditas Formation, Argentina by LEHNERT (1995a).

Specimens:

Sample KARM 6: Two possible damaged cusps of elements of a species of *Erismodus*.

Genus *Glyptoconus* KENNEDY 1980

Type Species: *Scolopodus quadraplicatus* BRANSON & MEHL 1933.

Glyptoconus quadraplicatus BRANSON & MEHL 1933
Plate 6.6, fig. 10.

Synonymy:

1933 *Scolpodus quadraplicatus* n. sp. BRANSON & MEHL; p. 63, Pl.4, figs.14, 15.

1978 *Scolpodus quadraplicatus* BRANSON & MEHL; FÅHRÆUS & NOWLAN, p. 468, Pl. 1, figs. 28, 30.

1980 *Glyptoconus quadraplicatus* (BRANSON & MEHL); KENNEDY, p. 62, 63, Pl. 1, figs. 39-45,

1980 *Scolpodus quadraplicatus* BRANSON & MEHL; REPETSKI & PERRY, Pl. 2, fig. 8.

1982 *Scolpodus quadraplicatus* BRANSON & MEHL; REPETSKI, p. 50, Pl. 23, figs. 4, 5.

1983 *Scolpodus quadraplicatus* BRANSON & MEHL; MOSKALENKO, p.114, 115, Pl. 25, figs. 3–5,

1986 *Glyptoconus quadraplicatus* (BRANSON & MEHL); SMITH & PEEL, Text–fig. 3A.

1988 *Glyptoconus quadriplicatus* (BRANSON & MEHL); STOUGE & BAGNOLI, p. 120, Pl. 3, figs. 20, 21. (*Syn.* to 1988).

1991 *Glyptoconus quadraplicatus* (BRANSON & MEHL); SMITH, p. 38–40, Text–figs. 22a–22d.

1993 *Glyptoconus quadraplicatus* (BRANSON & MEHL); FÅHRÆUS & ROY, p. 23, 24, Text–fig. 4.3.

1994 *Glyptoconus quadraplicatus* (BRANSON & MEHL); POHLER, Pl. 3, fig. 7.

1994 *Glyptoconus quadraplicatus* (BRANSON & MEHL); SEO et al., Figs. 11, 8–11.

1995a *Glyptoconus quadraplicatus* (BRANSON & MEHL); LEHNERT, p. 89–90, Pl. 2, figs. 15, 16, 18.

1996 *Glyptoconus quadraplicatus* (BRANSON & MEHL); LEHNERT & BORDONARO, Pl. 2, figs. 17–21.

Remarks:

The element is recorded as *Glyptoconus quadraplicatus* BRANSON & MEHL as it morphologically resembles the specimen in SEO et al., (1994, Figs. 11, 9). The specimen with its wing–like lateral costae resembles *Juanognathus variabilis* SERPAGLI. *Glyptoconus quadraplicatus* can be distinguished from this species as it haves a more rounded lateral costae and a straighter posterior basal edge. The basal cavity is almost circular (deformation) and the posterior basal margin is not turned upwards as is the basal edge of specimens of *Juanognathus variabilis*. The cusp of the Tasmanian specimen has a slight counterclockwise twist that is very similar the element discussed from Korea (SEO et al., 1994).

Age:

Glyptoconus quadraplicatus has been recorded from the *P. elegans* through to the *O. communis* Assemblage Zone in Argentina (LEHNERT 1995a). JI & BARNES (1994) recorded *Glytoconus quadraplicatus* within the Middle Canadian (*D. deltifer—O. evae)* from the Boat Harbour Formation, Canada.

SEO et al., (1994) defined the *Glyptoconus quadraplicatus* Assemblage Zone in Korea by the first appearance of the species within the Upper Tremadoc to the Lower Arenig (*D. deltifer* to the *P. elegans*? Assemblage Zone).

Specimen:
Sample KARM 5. One *a* element.

Genus *Juanognathus* SERPAGLI 1974

Type Species: *Juanognathodus variabilis* SERPAGLI 1974

Juanognathus jaanussoni SERPAGLI 1974
Plate 6.5, figs. 5, 6, 7, 8, 9.

Synonymy:

1965 *Acodus* n. sp. ETHINGTON & CLARK p. 187, Pl. 2, figs. 3, 4.

1970 Conodont undet. UYENO & BARNES; p. 118, 119, Pl. 22, figs. 16, 17.

1970 *Paltodus* n. sp. LEE; p. 331, Pl. 8, figs. 2a, b.

1974 "*Scandodus*" *robustus* SERPAGLI; ETHINGTON & CLARK, p. 94, Pl. 10, figs. 26–27, (*partim*).

1981 *Juanognathus jaanussoni* (SERPAGLI); ETHINGTON & CLARK, p. 50, Pl. 5, figs. 12, 13.

1982 *Juanognathus jaanussoni* (SERPAGLI); REPETSKI, pp. 26–27, Pl. 8, fig. 8,

1985 *Juanognathus jaanussoni* (SERPAGLI); AN et al., Pl. 5, figs. 7, 23,

1987*Juanognathus jaanussoni* (SERPAGLI); AN, p. 156, Pl. 10, figs. 18, 19 (?), Pl. 15, figs. 5, 7(?) (*cum syn.*).

1990 *Juanognathus jaanussoni* (SERPAGLI); AN & ZHENG, p. 167, Pl. 4, figs 20–22,

1993 *Juanognathus jaanussoni* (SERPAGLI); LEHNERT, Pl. 1, fig. 14.

1994 *Juanognathus jaanussoni* (SERPAGLI); POHLER, Pl. 3, fig. 13.

1995a *Juanognathus jaanussoni* (SERPAGLI); LEHNERT, Pl. 1, fig. 14.

1998b *Juanognathus jaanussoni* (SERPAGLI); ALBANESI, p. 125–126, Pl. 5, figs. 1–9,Text–fig. 13.

2003 *Juanognathus jaanussoni* (SERPAGLI); PYLE & BARNES, p. 149, fig. 3.

Remarks:

The posterior side of the element is rounded along its entire length and the upper cusp is twisted clockwise. On some anterior surfaces fine grooves or striae may be evident. Lateral costae are present ending at the upper part of the basal cavity. The elements closely follow the Transition Series of ALBANESI (1998b, p. 125). The *b* element in Pl. 6.4, fig. 12, from the Karmberg Limestone is a robust element with the posterior edge of the basal rim upturned. The *e* elements (Pl. 6.5, figs. 7, 8, and 9) have the enlarged rounded anterior surface.

Age:

In Argentina *Juanognathus jaanussoni* SERPAGLI has been recovered from the *Oepikodus evae, O. intermedius, M. parva* and the *E. variabilis* Conodont Zones (Middle Arenig to Early Darriwilian, (ALBANESI 1998b).

REPETSKI (1982) recorded *Juanognathus jaanussoni* SERPAGLI in Fauna 1 (*O. evae* to the *P. triangulodus* Zone) in the uppermost part of the El Paso Formation, U.S.A.

J. jaanussoni has been recovered from the base of the *J. gananda* Zone (Upper *O. communis* Zone) in the Skopi Formation, British Columbia, Canada (PYLE & BARNES 2003).

Specimens:

Sample KARM 5: One *e* element.
Sample KARM 5: One *a* element.
Sample KARM 6: One *c* element.
Sample KARM 6: One *e* element.
Sample KARM 6: One ?*e* element.

Juanognathus variabilis SERPAGLI 1974
Plate 6.6, figs. 1–9,

Synonymy:

1967 *Acontiodus* sp. B. IGO & KOIKE; p. 17, Pl. 2, fig. 15, text–fig. 4.
1967 *Scolopodus* sp. A. IGO & KOIKE, p. 26, Pl. 2, figs. 7a, b, text–fig. 5I
1974 Juanognathus variabilis n. sp. SERPAGLI; p. 49–50, Pl. 11, figs. 1a–7c, and i, Pl. 22, figs. 6-–17.
1990 *Juanognathus variabilis* (SERPAGLI); POHLER & ORCHARD, Pl. 3, fig. 18.
1998b *Juanognathus variabilis* (SERPAGLI); ALBANESI, p. 126, Pl. 5, figs. 1–14. (*syn.* to 1995a).
2003 *Juanognathus variabilis* (SERPAGLI); PYLE & BARNES, p. 149, fig. 3, p.150, fig. 4, Figs. 11.21–11.23.

Remarks:

SERPAGLI (1974) used *Scolopodus* sp. A and *Acontiodus* sp. B recorded from the

Langkawi Islands, Malaysia (IGO & KOIKE 1967) as the type species for the synonymy of *Juanognathus variabilis* SERPAGLI.

Age:

In Argentina ALBANESI (1998) recorded *Juanognathus variabilis* SERPAGLI within the *M. parva* to *E. variabilis* Conodont Zone (Late Arenig to very Early Darriwilian).

WANG & BERGSTRÖM (1999) is a revision of the Ordovician Conodont Zones within the Yangtze Area recorded *Juanognathus variabilis* within the earliest *P. originalis* Zone.

POHLER & ORCHARD (1990) recorded *Juanognathus variabilis* in the Broken Skull Formation in Canada. The Formation contained a mixed fauna that was composed of elements from both the North Atlantic and the North American Midcontinent conodont communities. There is some uncertainly concerning the age of the fauna. A suggested age of Fauna D and E (*P. proteus* to *O. evae* Zone) of ETHINGTON & CLARK (1981) has been suggested for this fauna.

J. variabilis ranges from the *B. extensus* to the middle *J. gananda* Zone (Upper *O. communis* Zone) in the Skopi Formation, British Columbia, Canada (PYLE & BARNES 2003).

Specimens:

Sample KARM 2: Two *a* elements.
Sample KARM 6: One *a* element.
Sample KARM 8: One *a* element.
Sample KARM 5: One *a* element.
Sample KARM 1: One *a* element.
Sample KARM 1. One *b* element.
Sample KARM 4: One *c* element.
Sample KARM 6: One *e* element.

Genus *Jumudontus* COOPER 1981

Type species: *Jumudontus gananda* COOPER 1981.

Jumudontus gananda COOPER 1981

Plate 6.7, fig. 1.

Synonymy:

?1970 *Spathognathodus* sp. cf. & nov. sp. LINDSTRÖM; LEE, p. 336, 337, Pl. 8, fig. 13.

1981 *Jumudontus gananda* sp. nov. COOPER; p. 170. 172, Pl. 31, fig. 13 (*cum syn.*)

1981 *Jumudontus gananda* (COOPER); ETHERINGTON & CLARK, p. 51, 52, Pl. 2, fig. 9, 10. (*Syn.* to 1981)

1988 *Jumudontus gananda* (COOPER); BERGSTRÖM, Pl. 3, fig. 48,

1990 *Jumudontus gananda* (COOPER); AN & ZHENG, p. 168, Pl. VIII, figs. 11–15, (*cum syn.*)

1995a *Jumudontus gananda* (COOPER); LEHNERT, p. 94, Pl. 8, fig. 16. (*cum syn.*)

1998b *Jumudontus gananda* (COOPER); ALBANESI, p. 162–163, Pl. 14, figs. 13–14. (*cum syn.*)

2003, *Jumudontus gananda* (COOPER); PYLE & BARNES. p. 149, fig. 3, p. 150, fig. 4, Fig. 11. 23

Remarks:
The damaged element is classified as part of a Pa element (ozarkodiniform) of the species *Jumudontus gananda* COOPER. The specimen from Tasmania is part of a robust bar with short, erect denticles. The element is spathognathodontiform in shape and the denticles are erect as shown in the specimen from the Argentina (LEHNERT 1995c, Pl. 8, fig. 16).

Age:
Jumudontus gananda COOPER is found in Lower to Middle Ordovician strata. In Argentina the species has been recorded from the *T. laevis* Zone in the Middle Arenig (ALBANESI 1998b).

In Australia *Jumudontus gananda* COOPER has been recorded from the OCD to the middle OCE from the Horn Valley (Informal Conodont Zones of MCTAVISH & LEGG 1976). This is an age range of Middle Arenig to Late Arenig (*B. navis* to the *O. evae*) (COOPER 1981, In: WATSON 1988).

Jumudontus gananda COOPER has been recorded from the base of the *J. gananda* Zone in the Skopi Formation and from the Uppermost *J. variabilis* Subzone in the Kechika Formation, British Columbia, Canada (PYLE & BARNES 2003.).

Specimen:
Sample KARM 8: One fragment of a Pa element.

Genus *Oepikodus* LINDSTRÖM 1955

Type Species: *Oepikodus smithensis* LINDSTRÖM 1955

Oepikodus communis ETHINGTON & CLARK 1964.
Plate 6.7, fig. 2

Synonymy:

1964 *Gothodus communis* n. sp. ETHINGTON & CLARK, p. 690–692, Pl. 114, figs. 6, 14, Text–fig. 2F.

1964 *Oepikodus equidentatus* n. sp. ETHINGTON & CLARK, p. 692–693, Pl. 113, figs. 6, 8, 10, 11, 14.

1982 *Oepikodus communis* (ETHINGTON & CLARK); REPETSKI, p. 30–31, Pl. 11, figs. 5–8, 10, 12, (*cum syn.*).

1988 *Oepikodus communis* (ETHINGTON & CLARK); STOUGE & BAGNOLI, p. 121, Pl. 5, figs. 8–12.(*cum syn.*).

1991 *Oepikodus communis* (ETHINGTON & CLARK); SMITH, p. 44–45, figs. 24 a–f, i, j, 25, 26. (*cum syn.*).

1991 *Oepikodus communis* (ETHINGTON & CLARK); BARNES et al., Pl. 1, figs. 20–27.

1994 *Oepikodus communis* (ETHINGTON & CLARK); POHLER, Pl. 5, figs. 4–6,

1994 *Oepikodus communis* (ETHINGTON & CLARK); JI & BARNES, p. 48–49, Pl. 14, figs. 1–16.

1995a *Oepikodus communis* (ETHINGTON & CLARK); LEHNERT, p. 98–99, Pl. 5, figs. 22, 27–29, Pl. 8, figs. 19–24. (*cum syn.*).

1998b *Oepikodus communis* (ETHINGTON & CLARK); ALBANESI, p. 153, Pl. 6, figs. 6–10.

Remarks:

The synonymy and the diagnosis of elements of *Oepikodus* are fully discussed in REPETSKI (1982). The M element of *Oepikodus communis* ETHINGTON & CLARK from the Karmberg Limestone is distinguished from elements of *Prioniondus* by the lack of denticles (SERPAGLI 1974, FÅHRÆUS & NOWLAN 1978, and REPETSKI 1982).

Age:

Oepikodus communis ETHINGTON & CLARK has been recorded from the *P. elegans* the *O. communis* to the *O. evae* Assemblage Zone in Argentina (LEHNERT 1995a) and the *P. elegans,* to *O. evae* Assemblage Zone within the San Juan Formation (ALBANESI 1998b).

Specimen:

Sample KARM 6: One specimen of an M element.

Oepikodus evae LINDSTRÖM 1955
Plate 6.7, fig. 12.

Synonymy:

1955 *Oepikodus smithensis* n. sp. LINDSTRÖM; p. 571–572, Pl. 6, figs. 1–3.

1955 *Oistodus longiramis* n. sp. LINDSTRÖM; p. 579, Pl. 4, figs. 35–37.

1995 *Prioniodus evae* n. sp. LINDSTRÖM; p. 589–590, Pl. 6. figs. 4–10.

1974 *Prioniodus (Oepikodus) evae* (LINDSTRÖM); SERPAGLI, p. 67–69, Pl. 15, figs. 9a–13, Pl. 26, figs. 1–10, Pl. 31, fig. 1,

1974 *Prioniodus (Oepikodus) evae* (LINDSTRÖM); LÖFGREN, p. 79–80, pl. 9, figs. 7–11, 17A, B (*cum syn.*).

1981 *Oepikodus evae* (LINDSTRÖM); LEMOS, p. 39–40, est. 1, 7–11.

1987 *Oepikodus evae* (LINDSTRÖM); AN, p. 159–160, Pl. 21, figs. 8–16. (*cum syn.*)

1988 *Oepikodus evae* (LINDSTRÖM); STOUGE & BAGNOLI, p. 121–122, Pl. 5, figs. 1–7, (*cum syn.*).

1990 *Oepikodus evae* (LINDSTRÖM); POHLER & ORCHARD, Pl. 3, fig. 16.

1993 *Oepikodus evae* (LINDSTRÖM); LEHNERT, Pl. 11, figs. 7–10.

1994 *Oepikodus evae* (LINDSTRÖM); LÖFGREN, Fig. 8, 13–15.

1994 *Oepikodus evae* (LINDSTRÖM); POHLER, Pl. 5, figs. 7–9.

1995a *Oepikodus evae* (LINDSTRÖM); LEHNERT, p. 99–100, Pl. 20B, fig. 1, (*cum syn.*)

1995 *Oepikodus evae* (LINDSTRÖM); WANG & BERGSTRÖM, Pl. 6, figs. 1–5.

1996 *Oepikodus evae* (LINDSTRÖM); LÖFGREN, fig. 5AF.

1998b *Oepikodus evae* (LINDSTRÖM); ALBANESI, p. 154–155, Pl. 6, figs. 11–19.

Remarks:

Only an M element of *Oepikodus evae* LINDSTRÖM was recorded from the Karmberg limestone from the Florentine Valley. Only the upper cusp of the element was recovered. There is an angle of approximately 60°–70° between the cusp and the elongated posterior process. The angle would indicate that the element may be an element of *Prioniodus (Oepikodus) evae* (SERPAGLI 1974, p. 72).

The Karmberg element forms a straight line along the basal margin. The element illustrated in SERPAGLI (1974, Pl. 26, fig. 9) has a recurved posterior process forming an angle of approximately 60°.

Oepikodus evae has been recorded from the Horn Valley, central Australia (COOPER 1981). The rounded costae on the lateral face of COOPER'S (1981) element is very similar to the costae on the specimen from the Karmberg Limestone, Tasmania. The Karmberg element has a smaller angle between the cusp and the posterior process of approximately 30°.

Age:

Oepikodus evae is an important index fossil having a short stratigraphical time range and a world wide geographical distribution. On a world wide basis it is an important species for the correlation of the *O. evae* Conodont Zone (Middle Arenig).

Specimen:

Sample KARM 10: One damaged M element.

Oepikodus sp.

Plate 6.7, figs. 3, 4.

Remarks:

The M elements show the acute angle between the cusp and the posterior lateral process. The anterior margin is sharp and slightly convex (Pl. 6.7, fig. 3). The basal cavity of the element in Plate 6.7, fig. 4 shows a slight basal flaring at the anterior end.

Specimens:

Sample KARM 8: One M element.

Section KARM 10: One M element.

Genus *Oistodus* PANDER 1856

Type Species: *Oistodus lanceolatus* PANDER 1856

"*Oistodus*" *hunickeni* SERPAGLI 1974

Plate 6.7, fig. 5.

Synonymy:

1974 " *Oistodus*" *hunickeni* n. sp. SERPAGLI; p. 54, 55, Pl. 13, figs. 1a–3b, Pl. 23, figs. 6, 7.

1981 "*Oistodus*" *hunickeni* (SERPAGLI); ETHINGTON & CLARK, p. 67, Pl. 7, fig. 8.

1991 "*Oistodus*" *hunickeni* (SERPAGLI); ALBANESI, p. 83, Pl. 6, figs. 7, 8.

1993 "*Oistodus*" *hunickeni* (SERPAGLI); LEHNERT, Pl. 2, fig. 11.

1995a "*Oistodus*" *hunickeni* (SERPAGLI); LEHNERT, p. 100.

Remarks:

The Tasmanian specimen is in agreement with the elements described from Argentina by SERPAGLI (1974). The element is robust, reclined at approximately 60° and is sharply keeled posteriorly. The lateral basal edge is flared at the mid point. At the anterobasal corner the edge is rounded and deflected laterally. The posterior edge is sharper that is the anterior edge.

Age:
"*Oistodus*" *hunickeni* has been recorded from Fauna B (*Prioniodus evae* Assemblage Zone) in Argentina (SERPAGLI 1974).

Specimen:
Sample KARM 6: One S element.

Oistodus cf. *lanceolatus* PANDER 1856
Plate 6.7, figs. 6, 7.

Synonymy:

1955a *Oistodus delta* n. sp. LINDSTRÖM; p. 573, 574, Pl. 3, figs. 3–9.
1955a *Oistodus lanceolatus* (PANDER); LINDSTRÖM, p. 577, Pl. 3, figs. 58–60.
1974 *Oistodus lanceolatus* (PANDER); VAN WAMEL, p. 75, Pl. 1, figs. 15–17.
1978 *Oistodus lanceolatus* PANDER); LÖFGREN, p. 63–64, Pl. 1, figs. 26–28, (*cum syn.*).
1982 *Oistodus* cf. *O. lanceolatus* PANDER); REPETSKI, p. 33, Pl. 11, fig. 13, Pl. 12, figs. 2, 4, 6–8.
1987 *Oistodus lanceolatus* (PANDER); AN, p. 160, Pl. 12, figs. 10–15. 24. (*cum syn.*).
1988 *Oistodus lanceolatus* (PANDER); BERGSTRÖM, Pl. 2, figs. 17–19.
1990 *Oistodus lanceolatus* (PANDER); POHLER & ORCHARD, p. 5, fig. 14.
1993b *Oistodus lanceolatus* (PANDER); LÖFGREN, fig. 6. 38–40.
1995a *Oistodus* cf. *lanceolatus* (PANDER); LEHNERT, p. 101, Pl. 3, figs. 21, 22.
1993b *Oistodus* aff. *lanceolatus* (PANDER); LEHNERT, p. 101, Pl. 7, figs. 1–5.
1998b *Oistodus lanceolatus* (PANDER); ALBANESI, p. 163, Pl. 7, figs. 1–5.

Remarks:
Oistodus lanceolatus PANDER is a well documented multielemental species with a full Transition Series of elements. A complete synonymy has been documented above. There appear to be many variation concerning the morphology of this species as there is some confusion over the diagnosis of the elements.

Age:
Oistodus lanceolatus PANDER has been reported from the *T. laevis, B. navis, P. originalis, M. parva* to the *E. variabilis* Assemblage Zones (Middle Arenig to early Darriwilian) in Argentina by ALBANESI (1998b). In the Burke River region, Australia, DRUCE & JONES (1971) noted that *Oistodus lanceolatus* was no younger than the beginning of the *Cordylodus rotundus—C. angulatus* Assemblage Zone.

Specimens:
Sample KARM 7: One M element.
Sample KARM 10: One M element.

Genus *Oneotodus* LINDSTRÖM 1955

Type Species: *Distacodus ? simplex* FURNISH 1938.

"*Oneotodus*" *gracilis* FURNISH 1938.

Plate 6.10, figs. 4, 7, 8.

Remarks:
The elements are referred to as specimens of *Oneotodus gracilis* FURNISH. The cusps of the elements are more slender are longer than the cusps of the elements referred to as *Oneotodus ?nakamurai* NOGAMI.

Occurrence:
The species has been reported from the La Silla Formation of Argentina (LEHNERT 1995a).

Age:
In Argentina the species has been reported from the La Silla Formation Si–C section by LEHNERT (1995a) within the Middle Tremadoc (*Rossodus manitouensis* Assemblage Zone) of North America.

Specimens:
Sample KARM 8: One *a* element.
Sample KARM 7: One *a* element.
Sample KARM 6?: One *a* element.
Sample KARM 6?: One *e* element.

Oneotodus ? sp. cf. *O. nakamurai* LINDSTRÖM 1955

Plate 6.10, figs. 1-3, 5, 6, 9, 10, 11.

Synonymy:

1967 *Oneotodus nakamurai* NOGAMI; p. 216, 217, Pl. 1, figs. 9a–13, Text–fig. 3–E.

1980 *Teridontus nakamurai* (NOGAMI); MILLER; p. 34–35, Pl. 2, figs. 15, 16, Text–fig. 40.

1982 *Teridontus nakamurai* (NOGAMI); AN, p. 150, Pl. 14, figs. 1–5b, 7–11b, Pl. 15, fig. 11.

1980 "*Oneotodus*" *nakamurai* (NOGAMI); LANDING et al., p. 28, 30, Text–fig. 8A–C, (incl. syn. to 1980).

1981 *Oneotodus nakamurai* (NOGAMI); ETHINGTON & CLARK, p. 74, Pl. 8, figs. 14, 19.

1983 *Oneotodus nakamurai* (NOGAMI); LANDING, p. 1178, figs. 11, L, M, R, W.

Remarks:

The elements in Pl. 6.10, figs. 1-3, 5, 6, 10, 11, are tentatively referred to as specimens of *Oneotodus ?nakamurai* NOGAMI because they are morphologically similar to the element illustrated in LANDING (1983). The cusps are reclined and show fine, longitudinal striae along the lateral sides of the cusp. The elements show the thickened basal rim which is turned upwards on the posterior side of the element.

Age:

LANDING (1983) noted that *Oneotodus nakamuri* was commonly found in association with conodont fauna at the Cambrian —Ordovician boundary.

Specimens:

Sample KARM 6: Two *a* elements.
Sample KARM 8: One *a* element.
Sample KARM 4: One *a* ? element and three *a* elements.

Genus *Paltodus* PANDER 1856

Type species: *Paltodus subaequalis* PANDER 1856

Paltodus sweeti SERPAGLI 1974.
Plate 6.7, figs. 8–11.

Synonymy:

1971 *Paltodus* sp. sp. B, ETHINGTON & CLARK; p. 67, 92, Pl. 2, fig. 13.

1974 *Paltodus sweeti* ? SERPAGLI; p. 58, 59, Pl. 14, figs. 133a–14b, Pl. 24, figs. 8–10, Text–fig. 12.

Remarks:

The elements are very similar to the elements illustrated in SERPAGLI (1974, Pl. 14, figs. 13a and 14a, and Pl. 24, fig. 8). The lateral faces of the cusp of the Tasmanian specimens are broadly rounded. The cusps have sharp, anterior and posterior edges. The basal cavity is small and the element in Pl, 7, figs. 9 and 10 shows some basal flaring on the inner side. The basal rim on the posterior side of the element has a small projection. The elements in Plate 6.7, fig. 8, 9, 10 are S elements and the element in Plate 6.7, fig.11 is an M element.

Age:
Paltodus ?sweeti was first recorded from the Early Arenig Faunas A and B, (*Prioniodus elegans* to *O. evae* Assemblage Zones) from the lower part of the San Juan Formation, Argentina (SERPAGLI 1974).

Specimens:
Sample KARM 8: One Sa element.
Sample KARM 2: One Sb element.
Sample KARM 9: One Sc element.
Sample KARM 6: One M element.

Genus *Paraprioniodus* ETHINGTON & CLARK 1981
Type species: *Tetraprioniodus costatus* MOUND 1965b.

Paraprioniodus n. sp.
Plate 6.11, fig. 1.

Remarks:
Only one element of *Paraprioniodus* sp. was recovered from the Karmberg Limestone. It is tentatively classified as a species of *Paraprioniodus* because of the long slender cusp and the large number of small, slender peg–like denticles which only occur on the posterior process.

Specimen:
Sample KARM 2. Only one specimen was recovered.

Genus *Polonodus* DZIK 1976
Type Species: *Ambalodus clivosus* VIIRA 1974.

?Polonodus sp.
Plate 6.11, figs. 8, 9, 10.

Synonymy:
1967 *Ambalodus* n. sp. VIIRA; fig. 3, 24a, b.
1985 *Polonodus* ? sp. LÖFGREN; Pl. 4, figs. AAB–AAE

Remarks:
The elements recovered from the Karmberg Limestone are morphologically similar to the *Polonodus* specimens reported from Argentina (ALBANESI 1998b) and the Table Point

Formation of Newfoundland (STOUGE 1984, Pl. 13, fig. 1). The basal cavity is large and morphologically similar to that of an element of *Polonodus*. Broad, flatter ridges are present but the crests, and tubercles are not present on the elements from the Florentine Valley Limestone. A low, main cusp is evident on the three specimens.

Age:

Possibly *E.*? *variabilis—M. parva* Subzone in Norway (RASMUSSEN 1991). In Argentina species of *Polonodus* are common within the *P. elegans* to the *O. communis* Assemblage Zone. ALBANESI et al., (1995a, 1998b) reported some species of *Polonodus* within the *P. elegans* to the *O. intermedius* Assemblage Zone (Early to Middle Arenig).

Specimens:

Three specimens were obtained from the Karmberg Limestone.
Sample KARM 1: One possible P specimen.
Sample KARM 6: One possible Pa–1 element.
Sample KARM 8: One specimen.

Genus *Protopanderodus* LINDSTRÖM 1971

Type Species: *Acontiodus rectus* LINDSTRÖM 1955

Protopanderodus elongatus SERPAGLI 1974

Plate 6.8, figs. 1–11, ?11, 13? Plate 6.20, fig. 11?

Synonymy:

1970 *Acontiodus* sp. D. HÜNICKEN & GALLINO; Pl. 2, fig. 1, fig. 2.
1971 *Oistodus* sp. E. HÜNICKEN; p. 44, 45, Pl. 1, fig. 10.
1974 *Protopanderodus elongatus* n. sp., SERPAGLI; p. 73–75, Pl. 16, figs. 8a–11c, Pl. 25, figs. 13–16, Pl. 30, fig. 16. (*cum syn.*).
1987 *Protopanderodus elongatus* (SERPAGLI); HÜNICKEN & SARMIENTO, p. 727, Pl. 1, figs. 24–25.
1990 *Protopanderodus elongatus* (SERPAGLI); SARMIENTO, Pl. 3, figs. 7–8.
1991 *Protopanderodus elongatus* (SERPAGLI); SMITH, p. 52, figs. 31a–c. (*cum syn.*).
1991 *Protopanderodus elongatus* (SERPAGLI); LEHNERT, Pl. III, figs. 14–15.
1994 *Protopanderodus elongatus* (SERPAGLI); POHLER, Pl. 6, figs. 3–4.
1998b *Protopanderodus elongatus* (SERPAGLI); ALBANESI, p. 128, Pl. 11, figs. 5–8, Text–fig. 14D.

Remarks:

Protopanderodus elongatus SERPAGLI have symmetrical and asymmetrical long, slender, simple cones forming a full range of elements in the Transition Series. The elements have lateral costae that may be unicostate or bicostate. The cusp tends to be slightly recurved and extends to a short base. *Protopanderodus elongatus* may be closely related to elements of *Scolopodus vulgaris* BRANSON & MEHL that have been identified from the Langkawi Islands (IGO & KOIKE 1967).

The elements in SERPAGLI (1974, Pl. 25, 13, 14, 15) are very similar to the elements of *Protopanderodus rectus* LINDSTRÖM described from the Miramichi Anticlinorium, (Tetagouche Group), Camel Back Mountain, New Brunswick by NOWLAN (1981, Pl. 1, fig. 6, 7, and Plate 3, figs. 10, 11).

An Assemblage plan for *Protopanderodus elongatus* SERPAGLI has been determined by ALBANESI (1998b, p. 127). The elements in the *c* and *f* positions tend to have a straight, longitudinal costae for most of the length of the cusp.

Age:

Protopanderodus elongatus SERPAGLI has been recorded within *P. originalis* to the *M. parva* Zone in the Niquivil Section of the San Juan Formation (LEHNERT1995a), and from the *P. proteus* (Sub Zone *O. elongatus* to the *A. deltatus*) through the *O. evae, O. intermedius* to the *T. laevis* Zone (ALBANESI 1998b).

Specimens:

Eleven specimens were from the Karmberg Limestone.
Sample KARM 10: One *e* element.
Sample KARM 8: One *e* ? element .
Sample KARM 6: Two *a–b* elements.
Sample KARM 4: One damaged *a–b* element.
Sample KARM 2: One damaged *a–b* element.
Sample KARM 10: One damaged *a–b* element.
Sample KARM 1: One *c* element.
Sample KARM 6: One *f* element.
Sample KARM 9: One *a–b* element.
Sample KARM 6: One *a–b* element.

Protopanderodus gradatus SERPAGLI 1974

Plate 6.8, figs. 12, 13, Plate 6.9, figs. 1–10, ?11, 12, 13, Plate 6.11, figs. 6, 7.

Synonymy:

1941 *Cordylodus simplex* (BRANSON & MEHL); GRAVES & ELLISION, p. 3, Pl. 1, figs. 4? 11.

1967 ?*Paltodus variabilis* (FURNISH); HIGGINS, text–fig. 2, (7),

1974 *Protopanderodus gradatus* SERPAGLI; p. 75–77, Pl. 5, figs. 5a–8b, Pl. 26, figs. 11–15, Pl. 30, figs. 1a, b.

1987 *Protopanderodus gradatus* (SERPAGLI); AN, p. 172, Pl. 10, figs. 24, 29 cum. syn.

1995a *Protopanderodus gradatus* (SERPAGLI); LEHNERT, p. 117, (*cum syn.* to 1993).

1994 *Protopanderodus gradatus* (SERPAGLI); POHLER, Pl. 6, fig. 5.

1995a *Protopanderodus gradatus* (SERPAGLI); ALBANESI, Pl. 3, figs. 5–6.

1998b *Protopanderodus gradatus* (SERPAGLI); ALBANESI, p. 128–129, Pl. 11, figs. 13–16, Pl. 15, figs. 12–13, Text–fig. 14B.

Remarks:

Protopanderodus gradatus SERPAGLI has an Assemblage Series with assymetrical to almost symmetrical simple cones. The cusps of the elements are long and slender, suberect to recurved, and fine longitudinal grooves on the cusp. The base is short and expanded at the proximal end of the element. The grooves are separated by rounded costae on the lateral surfaces of the elements. The posterior margin is rounded and the anterior side is rounded basally. The basal cavity is seep conical and the apex is directed towards the anterior margin of the element.

Age:

Specimens from Argentina have been reported from his Conodont Zones B and C by SERPAGLI (1974). These coincide with the *O. evae—B. navis* North Atlantic conodont Assemblage Zone. The species were also recorded within the *P. elegans—O. communis* Assemblage Zone by LEHNERT (1995a) and within the *P. elegans* through to the *E. variabilis* Assemblage Zone (Middle Arenig to the Middle Darriwilian) in the San Juan Formation and the Gualcamayo Formation of Argentina (ALBANESI 1998b). Specimens of *Protopanderodus* cf. *gradatus* have been reported from the *O. evae—B. navis* Zone of SERPAGLI (1974) in Tasmania (STAIT 1976).

ALBANESI & BARNES (2000) noted that specimens of *Protopanderodus gradatus* from the La Gualcamayo Formation, Argentina have an extensive range from the middle of the *M. parva* Zone through to the *E. suecicus* Assemblage Zone.

P. gradatus from the Honghuayuan Formation and the Dawan Formation of south China range from the base of the *P. proteus, P. elegans, O. evae,* though the *B. navis* to the *M. parva* Zone in the Hubei District (AN et al., 1983).

Specimens:
Sample KARM 6: One *e* element.
Sample KARM 5: One *e* element.
Sample KARM 9: One *e* element.
Sample KARM 6: One *e* element.
Sample KARM 4: Three *c* elements.
Sample KARM 9. One damaged *c* element.
Sample KARM 6: One *e* element.
Sample KARM 4: One *a–b* element.
Sample KARM 6. One *f* element.
Sample KARM 7: One damaged *e* element.
Sample KARM 8: One damaged *c* element.
Sample KARM 4: One *a-b* element.
Sample KARM 6: One *f* element.
Sample KARM 7: One *c* element.

Protopanderodus sp. cf. *P. leei* REPETSKI 1982.
Plate 7.13, fig. 10.

Synonymy:

1982 *Protopanderodus leei* REPETSKI, p. 39-40, Pl. 18, figs. 8-11.

Remarks:
The basal part of the element is robust and enlarged. The element is an Sc element. The anterior edge is gently curved but becomes expanded immediately above the mid point before tapering towards the apex of the element. Fine, parallel striations occur on the lateral surfaces of the element. The element is comparable to the element in REPETSKI (1982, Pl. 18, fig. 11c).

Occurrence:
The species has been recorded in Korea (LEE 1970) and the El Paso Formation, Texas (REPETSKI 1982).

Age:
Protopanderodus cf. *P. leei* REPETSKI was reported from Fauna D (*P. proteus* to the *P. elegans* Zone) in the El Paso Formation, Texas (REPETSKI 1982).

Specimen:
Sample KARM 4. One acodontiform (Sc) element.

Protopanderodus cf. *primitus* COOPER 1981
Plate 6.11, figs. 2, 4, 5.

Synonymy:

1969 *Scolopodus* sp. nov. A. HILL et al., p. O14, Pl. OVII, fig. 13.
1974 "*Panderodus* " sp. SERPAGLI; p. 43, Pl. 24, figs.12, 12, Pl. 30, figs. 12, 13.
1975a *Panderodus striatus* (LEE); LEE, p. 89, Pl. 2, figs. 11, 13.
1983 *Scolopodus euspinus* (JIANG & ZHANG); AN et al., p. 140–141, Pl. 13, fig. 27, Pl. 14. figs. 1–8, Text-fig. 12, 3–4.
1983 *Scolopodus euspinus* (JIANG & ZHANG); AN; Pl. 11, figs. 7–11, 13, 14, 16.
1981 *Protopanderodus primitus* COOPER, p. 174, Pl. 27, figs. 3, 4.
1994 *Protopanderodus ? primitus* (COOPER): DRUCE & STAIT, p. 307, 308, figs. 13A–C, 18D, E, G–K. (*cum syn.*).

Remarks:
The two Sb? elements are robust elements with prominent lateral costae. The costae form prominent longitudinal furrows each side of the rounded poster side of the element. The posterior basal margin is enlarged and projects forward in a similar way to elements of *Protopanderodus varicostatus*.

Occurrence:
Protopanderodus primitus COOPER has been recorded from the Horn Valley, Australia (COOPER 1981) and the Coolibah Formation (DRUCE & STAIT 1994).

Age:
COOPER (1981) established a range for the Horn Valley Formation from the base of the *O. evae* to the Upper *B. navis* Conodont Assemblage Zone. STAIT & DRUCE (1994) correlated *Protopanderodus ?primitus* from within the Coolibah Formation with a similar species which ranged in age from within the Dumugol to the Maggol Formations of Korea. This suggests a range of possibly from the *G. quadriplicatus* to above the *T. dumugolensis* Zone in Korea (SEO et al., 1994) and to the lowermost part of the *O. evae* Zone in the Baltic region.

Specimens:
Sample KARM 6: One (Sb?) element.
Sample KARM 9: One (Sb?) element.

Protopanderodus rectus LINDSTRÖM 1955
Plate 6.20, figs. 1, 2.

Synonymy:

1955 *Acontiodus rectus* LINDSTRÖM; p. 549, Pl. 2, figs. 7-11, Text–fig. 3B.

1971 cf. *Protopanderodus rectus* (LINDSTRÖM); LINDSTRÖM; p. 50.

1974 *Protopanderodus rectus* LINDSTRÖM; VAN WAMEL, p. 93, Pl. 4, figs. 7–10.

1982 *Protopanderodus* cf. *P. rectus* LINDSTRÖM; p. 40, Pl. 17, fig. 9, Pl. 18, figs. 2–3.

1990 *Protopanderodus rectus* (LINDSTRÖM); STOUGE & BAGNOLI, p. 23, Pl. 8, figs. 1–5, (*cum syn.*).

1990 *Protopanderodus rectus* (LINDSTRÖM); POHLER & ORCHARD, Pl. 4, fig. 4,

1993b *Protopanderodus rectus* (LINDSTRÖM); LÖFGREN, Fig. 5, A–D.

1994 *Protopanderodus rectus* (LINDSTRÖM); LÖFGREN, Fig. 7, 7–10.

1994 *Protopanderodus rectus* (LINDSTRÖM); POHLER, Pl. 6, figs. 6–8.

1994 *Protopanderodus rectus* (LINDSTRÖM); ALBANESI & VICCARI, p. 131, Pl. 1, fig. 8.

1994a *Protopanderodus rectus* (LINDSTRÖM); DZIK, p. 72, Pl. 13, figs. 27–30, Text–fig. 10a, (*cum syn.*).

1995 *Protopanderodus rectus* (LINDSTRÖM); WANG & BERGSTRÖM, Pl. 7, fig. 16,

1998b *Protopanderodus rectus* (LINDSTRÖM); ALBANESI, p. 129, Pl. 11, figs. 9–12, Text–fig. 14C.

Remarks:

According to the Assemblage scheme proposed by ALBANESI (1994b, p. 127, Text–fig. 14) the element are both *e* elements. The cusps are recurved and the posterior basal edge is projected forward. The rim of the basal cavity is thickened in both elements.

Age:

Protopanderodus rectus has been recorded from the *P. elegans* through the *O. intermedius, B. navis, M. parva* and the *E. variabilis* Zones in Argentina. MARQUIS & NOWLAN (1991) suggested a Late Arenig to Early Darriwilian for their conodont fauna from the Melbourne Formation, Quebec.

Specimens:

Sample KARM 10: One specimen.

Sample KARM 8: One specimen.

Protopanderodus varicostatus? SWEET & BERGSTRÖM 1962

Plate 6.20, fig. 5.

Synonymy:

1962 *Scolopodus varicostatus* n. sp. SWEET & BERGSTRÖM, p. 1247, Pl. 168, figs. 4–9, Text–fig. 1: A, C, K.

1974 *Protopanderodus varicostatus* (SWEET & BERGSTRÖM); BERGSTRÖM, et al., Pl. 1, figs. 9, 10.

1987 *Protopanderodus varicostatus* (SWEET & BERGSTRÖM); AN, p. 173-174, Pl. 11, figs. 2, 3, (*cum syn.*)

1987 *Protopanderodus varicostatus* (SWEET & BERGSTRÖM); HARRIS et al., Pl. 2, figs. F–G.

1987 *Protopanderodus varicostatus* (SWEET & BERGSTRÖM); BAUER, p. 27, Pl. 3, figs. 19, 21–23, (*cum syn.*).

1994a *Protopanderodus varicostatus* (SWEET & BERGSTRÖM); DZIK, p. 74, Pl. 14, figs. 1–5, Text–fig. 11b (*cum syn.*).

1998b *Protopanderodus varicostatus* (SWEET & BERGSTRÖM); ALBANESI, p. 130, Pl. 16, figs. 21–22.

Remarks:
Protopanderodus varicostatus SWEET & BERGSTRÖM shows a wide variation in the morphology of the elements. The elements have pronounced lateral processes on each side of the element and the large, raised posterior basal edge and margin.

Age:
The age of *Protopanderodus varicostatus* SWEET & BERGSTRÖM ranges from the middle Darriwilian to the Early Caradoc in Europe and from the *E. variabilis* to the middle *Amorphognathus tvaerensis* Zone in the Yukon, U.S.A.

In the Las Plantas Formation of Argentina *Protopanderodus varicostatus* has been reported from the Middle Caradoc (*A. tvaerensis* Zone) by LEHNERT (1995a).

Specimens:
Sample KARM 4: One element.

Genus *Pteracontiodus* HARRIS & HARRIS 1965

Type Species: *Pteracontiodus aquilatus* HARRIS & HARRIS 1965

Pteracontiodus cryptodens MOUND 1965

Plate 6.11, figs. 8.

Synonymy:

1965b *Eoneoprioniodus cryptodens* MOUND; p. 197–198, figs. 1, 2.

1981 *Pteracontiodus cryptodens* (MOUND); ETHINGTON & CLARK, p. 88–89, Pl. 1, figs. 1–4, 6–10. (*cum syn.*).

1985 *Pteracontiodus cryptodens* MOUND); BERGSTRÖM & ORCHARD, Pl. 2.1, figs. 9, 10, 15.

1994 *Pteracontiodus cryptodens* (MOUND); POHLER, Pl. 6, figs. 18, 19, 21–23.

1994a *Pteracontiodus cryptodens* (MOUND); JI & BARNES, p. 55, Pl. 16, figs. 19–26.

1995a *Pteracontiodus cryptodens* (MOUND); LEHNERT, p. 119–120, Pl. 7. fig. 7, Pl. 13, fig. 13.

1995 *Pteracontiodus cryptodens* (MOUND); ORTEGA et al., Pl. 5, figs. 18–23.

1995a *Pteracontiodus cryptodens* (MOUND); ALBANESI et al., Pl. 3, figs. 12.

1998b *Pteracontiodus cryptodens* (MOUND); ALBANESI , p. 148–149, Pl. 10, figs. 25–32, Text–fig. 21.

2000 *Pteracontiodus cryptodens* (MOUND); ALBANESI & BARNES, p. 494, fig. 2.

Remarks:
The Sd element obtained from the Karmberg limestone is very similar to the Sd element in ALBANESI (1998b, Pl. 10, fig. 28). The Tasmanian element has thin, wing–like lateral costae that join the shorter lateral processes each side at the basal region. The longer, arching, posterior process is also evident.

Age:
LEHNERT (1995a) noted that specimens of *Pteracontiodus cryptodens* MOUND from the upper part of the San Juan Formation ranged from the *P. parva* Zone to the *A. variabilis* Zone. ALBANESI & BARNES (2000, p. 494, fig. 2) recorded *Pteracontiodus cryptodens* MOUND in the upper *M. parva* to the lowest *E. variabilis* Assemblage Zone (Uppermost Yapeenian to lower Darriwilian) within the Gualcamayo Formation in Argentina

Specimen:
Sample KARM 8: One element.

Genus *Reutterodus* SERPAGLI 1974

Type Species: *Ruetterodus andinus* SERPAGLI 1974

Reutterodus andinus SERPAGLI 1974

Plate 6.13, figs. 2–5.

Synonymy:

1941 ? *Drepanodus arcuatus* (BRANSON & MEHL); GRAVES & ELLISON, p. 3, 7, Pl. 1, figs. 1, 23? non 7.

1974 *Reutterodus andinus* SERPAGLI ; p. 79–80, Pl. 17, figs. 9a–d, Pl. 28, figs. 1–9b, Text–figs. 19, 20.

1982 *Reutterodus andinus* ? (SERPAGLI); REPETSKI, p. 41, Pl. 18, fig. 7, Pl. 19, figs. 1–3.

1987 *Reutterodus andinus* (SERPAGLI); HÜNICKEN & SARMIENTO, p. 628, Pl. 1, figs. 11–14.

1988 *Reutterodus andinus* (SERPAGLI); STOUGE & BAGNOLI, p. 138, Pl. 10, fig. 8.

1990 *Reutterodus andinus* (SERPAGLI); SARMIENTO, Pl. 3, fig. 9.

1990 *Reutterodus andinus* (SERPAGLI); POHLER & ORCHARD, Pl. 5, fig. 18.

1991 ?*Reutterodus andinus* (SERPAGLI); SMITH, p. 58, figs. 34a–b (*cum syn.*).

1993 *Reutterodus andinus* (SERPAGLI); LEHNERT, Pl. 3, fig. 19, Pl. 4, fig. 1.

1995 *Reutterodus andinus* (SERPAGLI); LEHNERT & KELLER, p. 268, 269.

1995a *Reutterodus andinus* (SERPAGLI); LEHNERT, p. 122, Pl. 7, figs. 9–13.

1997 *Reutterodus andinus* (SERPAGLI); LEHNERT, et al., p. 57.

1998b *Reutterodus andinus* (SERPAGLI); ALBANESI, p. 178–179, Pl. 11, figs. 21–28, Text–fig. 34.

Remarks:

SERPAGLI (1974) identified three main types of elements for *Reutterodus andinus*.

1. Cones–shaped elements.

The elements have a flattened cusp. The anterior margin is rounded and the lateral sides have sharp costae that are keel–like at the base. These project forward on the posterior side of the element to form short, lateral processes. The basal cavity is almost at right angles to the margin of the short, posterior process.

2. Unibranched elements.

The cusp is shorter and one of the lateral, posterior processes has become extended and may have 8–10 denticles on the upper edge. The other lateral process is not denticulated. The basal margin is more upturned and exists as a shallow groove along the base of the element and both lateral processes.

3. Bibranched Elements.

These elements are arched with two posterolateral processes. The processes form an angle with each other from 50° to 90° to each other. Each process has 8–12 sharp denticles. The largest denticles are situated in the middle of each process. The cusp is much shorter and the basal cavity is more pit–like and the basal grooves extend outwards along the lateral processes. One element in Pl. 7.13, fig. 2 shows a possible "juvenile form" which may indicate the early formation of a bibranched element.

Based upon ALBANESI'S (1998b, p.178, text–fig. 34) multielement classification the Tasmanian elements recovered are either P, Sb and M elements. The elements from the Karmberg Limestone, Tasmania are either cones or unibranched elements. These elements are very similar to those from Argentina reported in SERPAGLI (1974), LEHNERT (1995a), and ALBANESI (1998b).

Age:

Reutterodus andinus SERPAGLI has been recorded from the Early to Middle Ordovician conodont fauna from the Broken Skull Formation in the Selwyn Basin of north western Canada. The species are associated with fauna that indicates an age of within the *P. elegans* to the *O. evae* Zone.

Reutterodus andinus SERPAGLI is common in San Juan Formation of Argentina and is located within the *P. proteus*, *P. elongatus* to the *O. evae* Assemblage Zones (Early to Middle Arenig) (ALBANESI 1998b).

LEHNERT & KELLER (1993) recorded *Reutterodus andinus* SERPAGLI from both the Niquivil and the Rio Sasso sections in Argentina. *Reutterodus andinus* SERPAGLI from the Rio Sasso Section was recorded within the *B. navis* to the *B. triangularus* Zone and from the *P. originalis* to the *M. flabellum parva* Zone in the Niquivil Section of the San Juan Formation.

LEHNERT (1995a) recorded *Reutterodus andinus* SERPAGLI from the *P. elegans* to the *O. communis* Assemblage Zone and LEHNERT et al., (1997) recorded *Reutterodus andinus* SERPAGLI from the *P. elegans—O. communis* Zone Argentina. The species is an important representative of the *O. evae* Zone in Argentina (LEHNERT 1995a).

PERCIVAL et al., (1999) and ZHEN et al., (in press) recorded *Reutterodus* cf. *andinus* from the conodont fauna from the Hensleigh Siltstone of N.S.W., Australia.(Bendigonian, Be1 to Be2 age, Lower Arenig) and as *Reutterodus* sp. from limestone samples with the Fairbridge Volcanics of Central NSW which has an age of no older than the Darriwilian.

Specimens:

Sample KARM 9: One M element.

Sample KARM 6: Two Sb elements.

Sample KARM 6: One M element.

Genus *Rossodus* REPETSKI & ETHINGTON 1983

Type Species: *Rossodus manitouensis* REPETSKI & ETHINGTON 1983

Rossodus manitouensis REPETSKI & ETHINGTON, 1983

Plate 6.12, figs. 1–7, 8? 9, 10. Plate 6.20, fig. 7.

Synonymy:

1981 New genus A, n. sp. A REPETSKI & PERRY; p. 14–16, Pl. 1, figs. 4, 6, Pl. 2, figs. 11, 12, 15.

aff. 1983 *Rossodus manitouensis* REPETSKI & ETHINGTON; p. 289–301, Figs. 1A–IV, 2A–2T, 3A–3R, 4A–4D.

aff. 1986 *Rossodus manitouensis* (REPETSKI & ETHINGTON); LANDING et al., p. 1940, Pl. 2, figs. 10, 11, 14, 18.

aff. 1988 *Rossodus manitouensis* (REPETSKI & ETHINGTON); REPETSKI, Abb. 2R–2V.

aff. 1988 *Rossodus manitouensis* (REPETSKI & ETHINGTON); ORNDORFF p. A14, A15, Pl. 2, figs. 9–11.

aff. 1990 *Rossodus manitouensis* (REPETSKI & ETHINGTON); POHLER & ORCHARD, Pl. 1, figs. 9, 10.

1995 *Rossodus manitouensis* (REPETSKI & ETHINGTON); POHLER, Pl. 6, fig. 24.

aff. 1995 *Rossodus manitouensis* (REPETSKI & ETHINGTON; LEHNERT, p. 121–122, Pl. 1, fig. 9.

aff. 1997 *Rossodus manitouensis* (REPETSKI & ETHINGTON); LEHNERT et al., Pl. 2, figs. 25A–26C.

Remarks:

Elements of *Rossodus manitouensis* REPETSKI & ETHINGTON have a thicker basal margin. In some elements a prominent, raised basal lip is evident on the basal margin of the element. The *b* elements collected from the Karmberg Limestone, Tasmania are very similar to the elements from the Survey Peak Formation (In: JI & BARNES 1991, Fig. 12: 15).

Age:

REPETSKI & ETHINGTON (1983) noted that *Rossodus manitouensis* has a cosmopolitan distribution. The *Rossodus manitouensis* Zone has been established within the North American Midcontinent fauna in some conodont Zonations (ALBANESI et al., 1998, p. 43 and SEO et al., 1994, fig. 6).

Rossodus manitouensis from the Cows Head Formation of Newfoundland was reported within a Midcontinent Fauna C (*C. angulatus* Zone) (POHLER 1994). JI & BARNES (1994) reported *Rossodus manitouensis* from the *C. angulatus* Zone in the Watt's Blight Formation, St. George Group of western Newfoundland.

LEHNERT (1995) noted the specimen to be associated with conodonts which are typical of Fauna D (ETHINGTON & CLARK1971) from the Middle Tremadoc (*Loxodus bransoni* or *Rossosodus manitouensis* Assemblage Zone).

Rossodus manitouensis specimens from the Survey Peak region of Canada were recovered from elements within upper part of Fauna C and in the Putty Shale Member and in the lower part of Fauns D of ETHINGTON and CLARK (1981) in the Middle Limestone Member (Lower *Loxonodus bransoni* and "*Scolopodus*" *quadriplicatus* aff. *Scolopodus rex* intervals.

Specimens:

Nine specimens were recovered from the Karmberg Limestone of Tasmania.

Sample KARM 2: One *a* element.

Sample KARM 3: One *b* element.

Sample KARM 6: One *b* element.

Sample KARM 4: Two *e* elements.

Sample KARM 5: One *b* element.

Sample KARM 8: Two *e* elements.

Sample KARM 8: Two *b* elements.

Genus *Scalpellodus* DZIK 1976

Type species: *Protopanderodus latus* VAN WAMEL 1974.

Scalpellodus tersus ZHANG

Plate 6.14, figs. 1–10,

Remarks:

The elements of *Scalpellodus tersus* ZHANG are very similar to the elements from Korea (in SEO et al., 1994, Fig. 10, 21–23). *Scalpellodus tarsus* ZHANG has a full Transition Series of elements. The elements illustrated show variation in the width of the bases. The micro ornamentation of fine striations which are parallel to the axis of the cusp are evident on the lateral surfaces of the elements. In this regard they are comparable to those described by LÖFGREN (1978). P and S elements were recorded from the Karmberg Limestone.

Occurrence:

Scalpellodus tersus has been recorded from the Dumugol Formation of Korea (Seo et al., 1994).

Age:

The species has been recorded within the *Triangulodus dumugolensis* Zone (middle of the *P. elegans* Zone to the lower part of the *O. evae* Assemblage Zone) in Korea. (Seo et al., op. cit.).

Specimens:
Section KARM 4: One Pa element.
Section KARM 10: One Pa element.
Section KARM 10: Two Sb elements.
Section KARM 8: One Sc element.
Section KARM 4: Three Sc elements.
Section KARM 8: One Sd element.
Section KARM 6: One Sd element.

Scalpellodus sp. cf. *S. tersus* ZHANG
Plate 6.13, fig. 9, Plate 6.20, Fig. 9.

Remarks:
One element is a Sb element and the other is an Sa element. The posterior and anterior edges are sharp but not denticulated. Faint, longitudinal striae are visible of the lateral sides of the cusps of these elements.

Age:
As for *Scalpellodus tersus*.

Specimens:
Sample KARM 6: One Sb element.
Sample KARM 4: One Sa element.

Genus *Scandodus* LINDSTRÖM 1955
Type Species: *Scandodus furnishi* LINDSTRÖM 1971

Scandodus americanus SERPAGLI 1974
Plate 6.13, fig. 6.

Synonymy:

1971 ?*Oistodus linguatus* (LINDSTRÖM); ETHINGTON & CLARK, p. 66, 73, Pl. 2, fig. 20.

1974 *Scandodus americanus* SERPAGLI, p. 83–84, Pl. 16, Figs. 6A–7B, Pl. 26, figs. 16–17, Pl. 30, Fig. 10, Text–fig. 22.

Remarks:
The element from the Karmberg limestone is very similar to the element illustrated in

SERPAGLI (1974, p. 84, Text–fig. 22). Because of the similarity the element is tentatively placed within the genus *Scandodus*. The element is assymetrical, recurved with a broad and leaf-shaped surface on the cusp. A medial costae is visible.

Occurrence:
The species has not been widely reported but has been recorded from Argentina (SERPAGLI 1974) and in published and unpublished material from Newfoundland and possibly Nevada, U.S.A.

Age:
Scandodus americanus SERPAGLI was first recorded within Fauna A (Early Arenig, *P. elegans* Assemblage Zone) in Argentina (SERPAGLI 1974).

Specimen:
Sample KARM 8: One M? element.

Scandodus furnishi LINDSTRÖM 1955
Plate 6.13, fig. 8.

Synonymy:

1955 *Scandodus furnishi* LINDSTRÖM; p. 592, Pl. 5, fig. 3.
1974a *Scandodus furnishi* (LINDSTRÖM); SERPAGLI, Pl. 1, fig. 14.
1974b *Scandodus furnishi* (LINDSTRÖM); SERPAGLI, p. 85, Pl. 17, fig. 10a–c, Pl. 27, fig. 8.
1982 *Scandodus furnishi* (LINDSTRÖM); REPETSKI, p. 42, 44, Pl. 20, fig. 8.
1988 cf. *Scandodus furnishi* (LINDSTRÖM); STOUGE & BAGNOLI, p. 138, Pl. 15, fig. 12–14.
1993 "*Scandodus*" cf. *furnishi* (LINDSTRÖM); LEHNERT, Pl. 4, fig. 7.
1995a "*Scandodus*" cf. *furnishi* (LINDSTRÖM); LEHNERT, Pl. 4, fig. 7.

Age:
The species has been recorded from Argentina in Fauna A of SERPAGLI (1974,) (*P. elegans* Zone) and the III-IV Assemblage Zone (*O. evae to O. intermedius*) in the Niquivil Section of the San Juan Formation (LEHNERT 1993).

Specimens:
Sample KARM 8: One specimen referable to *S. furnishi* LINDSTRÖM.

Genus *Scolopodus* PANDER 1856

Type Species: *Scolopodus sublaevis* PANDER 1856

Scolopodus filosus ETHINGTON & CLARK 1964

Plate 6.15, figs. 1–4, ?5, Plate 6.17, fig. ?11.

Synonymy:

1964 Scolopodus filosus n. sp. ETHINGTON & CLARK, p. 699, Pl. 114, figs. 12, 17, 18, 19, Text–fig. 2E.

1964 *Scolopodus filosus* ETHINGTON & CLARK; p. 100.

1968 ?*Scolopodus filosus* (ETHINGTON & CLARK); MOUND, p. 418, Pl. 5, figs. 16, 20, 25, 28, 33, 39, 45, 46, 59.

1971 *Scolopodus filosus* (ETHINGTON & CLARK); JONES, p. 63, Pl. 5, fig. 9a–c, 10a–c, Pl. 6, figs. 1a–c.

1978 *Scolopodus filosus* (ETHINGTON & CLARK); FÅHRÆUS & NOWLAN, p. 468, Pl. 1, figs. 16, 17.

1982 *Scolopodus filosus* (ETHINGTON & CLARK); ETHINGTON & CLARK, p. 100, Pl. 11, fig. 22.

1994 *Scolopodus* sp. aff. *Scolopodus filosus* (ETHINGTON & CLARK); DRUCE & STAIT; p. 310, figs. 13G, 19A–E, K.

Remarks:

The elements are scolopodiform with a strong degree of basal curvature at the basal end of the element towards the posterior side of the element. The basal cavity is shallow and the basal region is approximately circular in cross section. The lateral costae are prominent and are continuous to almost the basal edge of the element. Fine striae are evident of the posterior surface of the element.

Age:

Scolopodus filosus has been reported from Fauna D fauna (*D. deltifer* to *P. proteus* conodont Zone), in the El Paso Formation, Texas (REPETSKI 1982).

Specimens:

Sample KARM 2: One Sd? element.

Sample KARM 4: Three elements.

Sample KARM 6: One element.

Sample KARM 10: One possible element.

Scolopodus floweri REPETSKI 1982.
Plate 6.15, fig. 9.

Synonymy:

1982 *Scolopodus floweri* n. sp. REPETSKI; p. 47-48, Pl. 24, figs. 7, 9, 10. Pl. 25, figs. 1, 4.

1997 *Scolopodus floweri* REPETSKI; LEHNERT et al., Pl. 2, figs. 10, 11.

Remarks:
Only one element of *Scolopodus floweri* REPETSKI was recovered from the Karmberg Limestone. The element is very similar to the element in REPETSKI (1982, Pl. 24, fig. 10). The element is reclined with a sharp anterior edge with several anterior costae evident towards the distal end of the element. The anterior basal rim shows evidence of thickening.

Occurrence:
Scolopodus floweri REPETSKI has only been reported from the El Paso Formation in Texas (REPETSKI 1982), the La Silla Formation, Argentina (LEHNERT 1995a) and from Tasmania.

Age:
Scolopodus floweri has been recorded within the *P. originalis* to the *M. parva* Conodont Assemblage Zone in the La Silla Formation, Argentina (LEHNERT 1997).

Specimen:
Sample KARM 8?: One element.

Scolopodus giganteus SWEET & BERGSTRÖM 1962
Plate 6.15, fig. 10.

Synonymy:

1962 *Scolopodus giganteus* SWEET & BERGSTRÖM; p. 1247, Pl. 169, fig. 14, Text–fig. 1J.

1967 *Scolopodus giganteus* SWEET & BERGSTRÖM; IGO & KOIKE, p. 23–24, Pl. II, figs. 2a, b, Text–fig. 5E, F.

1969 *Scolopodus giganteus* (SWEET & BERGSTRÖM); BRADSHAW, p. 1162, 1163, Pl. 132, fig. 7.

1970 *Scolopodus* n. sp. UYENO & BARNES; p. 116, 117, Pl. 22, figs. 3–5, Text–fig. 7A.

1973 *Protopanderodus* cf. *P. giganteus*, (SWEET & BERGSTRÖM); BARNES & POPLAWSKI, p. 782, Pl. 1, fig. 4.

1976 *Scolopodus giganteus* (SWEET & BERGSTRÖM); LANDING, p. 639–640.

Remarks:

The element of *Scolopodus giganteus* SWEET & BERGSTRÖM is large, robust, and bilaterally symmetrical. The surface of the cusp has longitudinal costae running the full length of the element. The basal region is enlarged and the basal rim is convex and the basal edges are sharp. The element is similar to the *e* elements of *Scolopodus kummi* LEHNERT (In: ALBANESI 1998b, Pl. 12, figs. 24, 25), and the element of *Scolopodus* cf. *rex* LINDSTRÖM (LEHNERT 1995a, Pl. 5, fig. 10).

Age:

Scolopodus giganteus is a long ranging species occurring in the Late–Early to Early Middle Ordovician conodont faunas in the U.S.A. Within the Tectagouche Group, Camel Back Mountain, Canada the species has a questionable range from the *P. variabilis* to the *P. alobatus* SubZone within the *A. tvarensis* Conodont Zone (NOWLAN 1981).

Specimen:

Sample KARM 9: One *e* element.

Scolopodus krummi LEHNERT 1995a

Plate 6.16, 12, Plate 6.17, figs. 5–8, 12.

Synonymy:

1965 *Scolopodus cornutiformis* (BRANSON & MEHL); ETHINGTON & CLARK, p. 200, Pl. 1, fig. 12,

1970 *Scolopodus rex* (LINDSTRÖM); LEE, p. 334, Pl. 8, figs. 8, 9.

1971 *Scolopodus cornutiformis* (BRANSON & MEHL); ETHINGTON & CLARK, Pl. 2, figs. 21, 22.

1995a *Tropodus ? krummi* n. sp. LEHNERT; p. 130-131, Pl. 5, figs. 18–19, (*cum syn.*)

1998b *Scolopodus krummi* (LEHNERT); ALBANESI, p. 131–132, Pl. 12, figs. 18–26, Tex–fig. 15. (*cum syn.*)

2003 *Scolopodus krummi* (LEHNERT); PYLE & BARNES, p. 149, fig. 3.

Remarks:

Most of the elements of *Scolopodus krummi* LEHNERT from the Karmberg Limestones are reclined, slender elements. The elements shown in Plate 7.16, figs. 8, 9, and Plate 7.17, fig. 9 from the Karmberg Limestones are similar to the *b* elements of ALBANESI (1998b, Pl.12, figs. 17, 18). *Scolopodus kummi* LEHNERT was erected as a new species in Argentina (LEHNERT 1995a).

Age:

The species has a range through the *P. proteus*, *P. elegans, O. evae* to the *O. intermedius* in the San Juan Formation of Argentina (ALBANESI 1998b).

Scolopodus krummi LEHNERT has been reorded from the Kechika and the Skoki Formations, British Columbia, Canada. The range extends from the *A. kechikaensis* Zone to the base of the *J. gananda* Zone (=lowermost *P. elegans* to Upper *O. communis* Zone) (PYLE & BARNES 2003).

Specimens:

Seven specimens were recovered from the Karmberg Limestone.

Sample KARM 2: One *a* element.

Sample KARM 4: Two *c* elements.

Sample KARM 6: One *f* element

Sample KARM 7: One *a* element.

Sample KARM 8: One *a* element.

Sample KARM 8: One *b* element.

Sample KARM 8: One *c* element.

Scolopodus rex LINDSTRÖM 1955

Plate 6.16, figs.1–10, Plate 6.17, figs. 1, 2, ?3.

Synonymy:

1995 *Scolpodus rex* n. sp. LINDSTRÖM, p. 595–596, Pl. 3, fig. 32.

1978 *Scolpodus rex* (LINDSTRÖM); LÖFGREN, p. 109–110, Pl. 1 figs. 38–39. (*cum syn.*)

1989 *Scolpodus rex* (LINDSTRÖM); KANYGIN et al., p. 121, Pl. XVII, fig. 8, Pl. XXI, figs. 10, 11.

1985 *Scolpodus rex* (LINDSTRÖM); STOUGE & BAGNOLI, p. 25, Pl. 9, figs. 1–6, (*cum syn.*).

1994 *Scolpodus rex* (LINDSTRÖM); LÖFGREN, fig. 7. 1.

1995 *Scolpodus rex* (LINDSTRÖM); ORTEGA et al., Pl. 5, fig. 13.

1994 *Scolpodus rex* (LINDSTRÖM); WANG & BERGSTRÖM, Pl. 7, fig 7.

1998b *Scolpodus rex* (LINDSTRÖM); ALBANESI, p. 133, Pl. 12, figs 14–17.

Remarks:

Scolopodus rex LINDSTRÖM is a robust, semi erect to proclined conical species. The anterior edge of the cusp is rounded and the cusp has quite distinct longitudinal costae on the surface of the element (LINDSTRÖM, In: LEHNERT 1995a, Pl. 5, figs. 5, 6). The elements from Argentina have rounded, incurving basal edges and regularly spaces, longitudinal costae on the surface of the cusp.

Age:
Scolopodus rex LINDSTRÖM has been reported from the Late Arenig to Early Darriwilian (*B. navis* through to the *E. variabilis* Assemblage Zones) within the San Juan and the Gualcamayo Formations of Argentina.

SEO et al., (1994) recorded *Scolopodus rex* LINDSTRÖM within the *Triangulodus dumugolensis* Zone that is Middle Arenig in age.

AN et al., (1985) reported *Scolopodus rex* LINDSTRÖM from the Lower Arenig of the Honghuayuan Formation, South China (*P. proteus* to the upper part of the *Paroistodus elegans* Zone).

WANG & BERGSTRÖM (1999) suggested that the range of *Scolopodus rex* from the Jianyangping Section of the Yangtze Platform of South China extended from the *P. originalis* to the *E. variabilis* Zone. The recorded the species from the lower part of the *Baltoniodus norrlandica —M. parva* Zone through to the upper *E. variabilis* Zone in Daping, South China. In the Huanghuachang Section the range of the species extended further up into the *E. crassus* Zone.

Specimens:
Sample KARM 4: Three *a* elements.
Sample KARM 4: Two *b* elements.
Sample KARM 5: One *a* ? element.
Sample KARM 5: One e? element.
Sample KARM 6: One *a* element.
Sample KARM 6: One *b* element.
Sample KARM ?6: One *f* element.
Sample KARM 7: One *a* element.
Sample KARM 7: One *e* element.
Sample KARM 7: One *f* element.
Sample KARM 8: One *a* element.
Sample KARM 10: One *e* element of *Scolopodus* sp. cf. *S. rex* (Pl. 7.17. fig. 3).

Genus *Semiacontiodus* MILLER 1969

Type Species: *Acontiodus nogamii* MILLER 1969.

"Semiacontiodus " cornuformis SERGEEVA 1963.
Plate 6.17, fig. 10.

Synonymy:

1963 *Scolopodus cornuformis* SERGEEVA; p. 93, Pl. 7, Fig.1–3, Text-fig. 1.
1967 *Scolopodus cornuformis* (SERGEEVA); VIIRA, Text-fig. 3.13–3.15.
1978 *Scolopodus cornuformis* (SERGEEVA); LÖFGREN, p. 105–107, Pl. 7, figs. 1–6, 9–12, Pl. 8, fig. 1, 2, 4–6.
1987 *Scolopodus cornuformis* (SERGEEVA); AN, p. 183, 184, Pl. 7, figs. 10, 11, 13–16.
1978 *"Semiacontiodus" cornuformis* (SERGEEVA); STOUGE & BAGNOLI, p. 26, Pl. 9, fig. 14–18, 20–25.
1995a *"Semiacontiodus " cornuformis* (SERGEEVA); LEHNERT, p. 125, 126, Pl. 7, fig. 22, Pl. 8, fig. 5, Pl. 9, figs. 14, 21, 22, Pl. 12, figs. 18, 19, 21, 23, 24.

Remarks:
The Karmberg element is an Sd element. It is very similar to the element in LEHNERT (1995b, Pl. 12, fig. 18). The element is long slender and reclined. The posterior side of the element is convex in outline and smooth. The posterior side is also convex in outline and the surface is covered with fine, longitudinal parallel striae. The element is damaged but the basal cavity is evident and is directed towards the mid point of the anterior side of the element.

Age:
LEHNERT (1995b) recorded *"Semiacontiodus" cornuformis* SERGEEVA from within the *M. parva* to the *A. variabilis* Assemblage Zone.

Specimen:
Sample KARM 6: One Sd element.

Genus *Stolodus* LINDSTRÖM 1971

Type species: *Distacodus stola* LINDSTRÖM 1955.

Stolodus sp. aff. *Stolodus stola* LINDSTRÖM 1955
Plate 6.18, fig. 7.

Synonymy:

1955a *Distacodus stola* LINDSTRÖM; p. 555, 557, Pl. 3, figs. 43–49.
1975 *Stolodus stola* (LINDSTRÖM); VAN WAMEL; p. 95–96, Pl. 8, fig. 23, (*partim*).

1976 *Stolodus* sp. aff. *Stolodus stola* (LINDSTRÖM); LANDING, p. 640, 641, Pl. 4, figs. 17, 18, 21.

1985 *Stolodus stola* (LINDSTRÖM); AN et al., Pl. 8, fig. 10.

1987 *Stolodus stola* (LINDSTRÖM); AN, p. 191–192, Pl. 22, figs. 20–23, Pl. 23, figs. 1–2.

1993 *Stolodus stola* (LINDSTRÖM); LEHNERT, Pl. 4, figs. 8, 12, 16.

1993 *Stolodus stola* (LINDSTRÖM); POHLER, Pl. 8, Fig. 4. (*partim*).

1995 *Stolodus stola* (LINDSTRÖM); WANG & BERGSTRÖM, Pl. 7, figs. 1, 6.

1995a *Stolodus stola* (LINDSTRÖM); LEHNERT, p. 126–127.

1998b *Stolodus stola* (LINDSTRÖM); ALBANESI, 112–113, Pl. 1, fig. 24, Pl. 13, figs. 8–10.

2003 *Stolodus stola* (LINDSTRÖM); PYLE & BARNES, p. 149, fig. 3,

Remarks:

Only one element that is referable to *Stolodus stola* LINDSTRÖM (1971) was recovered from the Karmberg Limestones. The element is typical of the species with the apex of the cusp being strongly recurved posteriorly and is slightly twisted in a counterclockwise direction. It is difficult to establish whether the basal cavity is shaped like a trapezium.

Age:

Stolodus aff. *stola* has been reported from the *O. evae—O. intermedius* Assemblage Zone in Argentina LEHNERT (1993). *Stolodus stola* from the Dawan Formation, South China ranges through the *O. evae* to the upper *B.* aff. *navis* Assemblage Zones.

Recently *Stolodus stola* has been reported from the upper part of the *A. kechikaensis* Zone (= basal P. elegans Zone) in the Kechika Formation, British Columbia, Canada (PYLE & BARNES 2003).

Specimen:

Sample KARM 5: One specimen.

Genus *Tasmanognathus* BURRETT 1979

Type species: *Tasmanognathus careyi* BURRETT 1979.

Tasmanognathus sp. BURRETT 1979.

Plate 6.13, fig. 1.

Remarks:

The element is similar to the Sa_1 element in BURRETT (1979, Pl. 1, figs. 18 and 19). The main cusp is erect, has a rounded anterior margin and is approximately one and one half times as long as either of the lateral processes. A sharp costae are evident on each side of the main cusp. This is evident at the apex of the broken main cusp. The denticles on the lateral processes are small and rounded to elliptical in cross section. The basal cavity is extends into the main cusp and extends as a narrow, shallow groove along each of the lateral processes. The walls of the element are thin and the element is easily damaged.

Occurrence:
Several species of the genus *Tasmanognathus* have been reported from Inner Mongolia (LIN et al., 1984), North China (AN et al., 1983, AN et al., 1985, BAOYU & HONGRONG 1989), and one from Tasmania (BURRETT 1979.).

Several species of the genus *Tasmanognathus* occur in shallow onshore and shallow water facies around the North China Platform (BAOYU & HONGRONG 1989).

Age:
BURRETT (op. cit.) correlated the species of *Tasmanognathus careyi* with Blackriveran conodont fauna from the Everlasting Hills of northern Tasmania and the Florentine Valley of central Tasmania.

Species of *Tasmanognathus* recorded from Northern China within the *Tasmanognathus borealis* Conodont Zone in the Yaoxian Formation (Upper Caradoc), the *Tasmanognathus shichuanheensis* Conodont Zone (Lower Caradoc) and the Upper Fengfeng Formation (Latest Darriwilian to the Middle Gisbornian).

In Tasmania BURRETT (1979) recorded specimens of *Tasmanognathus* from limestone containing *Phragmodus flexuosus* (*P. serra* to *P. anserinus* Zone) within Fauna 5 and 6 of SWEET & BERGSTRÖM (1976) and below the *Phragmodus undatus* or Fauna 8 (Upper Gisbornian) or younger. BURRETT (1979, p. 31) suggested an age of Fauna 8 for specimens of the genus *Tasmanognathus* from Tasmania.

Specimen:
Sample KARM 1: One trichonodelliform (Sa) element.

Genus *Teridontus* MILLER 1980

Type species: *Oneotodus nakamurai* NOGAMII 1967.

Teridontus nakamurai NOGAMI 1967

Plate 6.15, figs. 6, 7, 8.

Synonymy:

1967 *Oneotodus nakamurai* n. sp., NOGAMI, p. 216–217, Pl. 1, figs 9, 12, ?13.
Text–fig. 3A, B, ?C non text–fig. 3D, E, Pl. 1. fig. 10, 11.
{=*E. notchpeakensis*, MILLER; (1980), 22, 23, BUGGISCH & REPETSKI, (1987), 160}.

1980 *Teridontus nakamurai* (NOGAMI); MILLER, p.34, 35, fig. 40, Pl. 2, figs. 15, (*syn.* to 1980).

1986 *Oneotodus ? nakamurai* (NOGAMI); LANDING, et al., p. 1934, Pl. 1, figs. 1, 2.

1987 *Teridontus nakamurai* (NOGAMI); BUGGISCH & REPETSKI, p. 159, 160, Pl. 2, figs. 1, 3–8, 10–17, 19–21, Pl. 3, figs. 1–9, 17–20.

1987 *Teridontus nakamurai* (NOGAMI); BAGNOLI, et al., Pl. 2, figs 17, 18.

1987 *Teridontus nakamurai* (NOGAMI); BUGGISCH & REPETSKI, p. 159-160, Pl. 2, figs. 1, 3–8, figs. 10–17, 19–21. cf. figs. 2, 9, 18, Pl. 3, figs. 1–9, 16–20, cf. 10–15, Pl. 8, figs. 13, 14, Pl. 9, fig 10, 14.

1991 *Teridontus nakamurai* (NOGAMI); LANDING & BARNES, p. 1618, Pl. 1, figs. 16, 17.

1990 *Teridontus nakamurai* (NOGAMI); AN, p. 161, Pl. 1, figs.?3, 9, 10, ?11, ?12, 13, fig. 14.

1990 *Teridontus nakamurai* (NOGAMI); POHLER & ORCHARD, Pl. 2, fig. 9.

1994 *Teridontus nakamurai* (NOGAMI); LEHNERT, p. 225, 256, Pl. 1, figs. 5, 11.

1995a *Teridontus nakamurai* (NOGAMI); LEHNERT, p. 128–129, Pl. 1, fig 3, Pl. 14, fig. 3. (*cum syn.* 1981 to 1990).

Remarks:

The elements closely resemble the elements illustrated in LANDING & BARNES (1981, Pl. 1, figs. 16, 17). The cusps of the element are reclined and taper to a sharp point. The walls of the basal cavity are thin and in some elements the lateral faces of the base arch upwards. Fine striations are visible on the anterior surface of the cusp under higher magnification.

Teridontus nakamurai has been recovered from the Cape Clay Formation, southern Devon Island in the Arctic Archipelago (LANDING & BARNES 1981) and from Argentina (LEHNERT 1993, 1995a). *Teridontus nakamuri* is a common species from North Victoria Land, Antarctica (BUGGISCH & REPETSKI 1987).

Age:

Teridontus nakamurai (NOGAMI) has been recovered from the *Clavohamulus hintzei* Zone in the La Silla Formation of Argentina (LEHNERT 1995a).

LANDING & BARNES (1981) recorded *Teridontus nakamurai* (NOGAMI) within the Fauna C of the North American Midcontinent faunal Province of Late Tremadoc age.

BUGGISCH & REPETSKI (1987) recorded *Teridontus nakamurai* (NOGAMI) within the Upper Cambrian to the Temadoc within the limestone clasts from North Victoria Land Antarctica.

Specimens:
Sample KARM 4: One damaged S element.
Sample KARM 4: One Sc element.
Sample KARM 7: One P? element.

Genus *Triangulodus* VAN WAMEL 1974

Type Species: *Paltodus volchovensis* SERGEEVA 1963

Triangulodus cf. *Triangulodus brevibasis* SERGEEVA 1963
Plate 6.18, figs.1–6.

Synonymy:

1974 ? *Scandodus brevibasis* (SERGEEVA); SERPAGLI, p. 82–82, Pl. 18, figs. 5a–7c, figs. 10, 11, Pl. 30, figs. 2a–3, text–fig. 21.

1974 *Triangulodus brevibasis* (SERGEEVA); ZHANG, In: AN et al.,

1974 *Triangulodus brevibasis* (SERGEEVA); VAN WAMEL, p. 96–97, Pl. 5, figs. 3a, 3b.

1983 *Triangulodus* cf. *brevibasis* (SERGEEVA); ZHANG, In: AN et al., p. 158–159, Text–fig. 11, figs. 12–15. (*Syn.* to 1978).

1993 *Triangulodus* sp. cf. *brevibasis* (SERGEEVA); STAIT & DRUCE, p. 315, figs. 14D–F, 20J–L, N, O, 21K.

1993 *Triangulodus brevibasis* (SERGEEVA); LEHNERT, p. 129, Pl. 8, fig. 15.

Remarks:
The erect scandodiform (Sb) elements from the Karmberg limestone are very similar to the elements illustrated in STAIT & DRUCE (1993, fig. 21, I) and VAN WAMEL (1974, Pl. 5, figs. 3a and 3b). The lateral faces show a prominent costa on the inner side. The anterior and the anterior basal edges corners are sharper. The upper cusp has a slight clockwise twist.

Occurrence:
Triangulodus brevibasis has been reported from the San Juan Formation, Argentina as *Scandodus brevibasis* (SERPAGLI 1974), and from Sweden (VAN WAMEL 1974), and

North China (AN et al., 1983). *Triangulodus* sp. cf. *T. brevibasis* has been recorded from the Coolibah Formation, Central Australia (STAIT & DRUCE 1994).

Age:

Within the *Triangulodus brevibasis* Zone in Sweden by VAN WAMEL (1974). STAIT & DRUCE (1994) recorded *Triangulodus* sp. cf. *T. brevibasis* within the Middle to Late Arenig.

SERPAGLI (1974) recorded his specimens of *Scandodus brevibasis* within Fauna D (*P. originalis* Zone) within the San Juan Formation.

Specimens:

Sample KARM 4: One Sa element.
Sample KARM 4: One Sc element.
Sample KARM 6: One Sc element.
Sample KARM 7: One Sc element.
Sample KARM 8: One Sc element.
Sample SETT. 1 Cashions Creek Formation, Settlement Road. One element.

Triangulodus larapintinensis CRESPIN, 1943
sensu COOPER 1986.
Plate 6.18, fig. 8.

Synonymy:

1981 *Trigonodus laripintinensis* (CRESPIN); COOPER, p. 180, Pl. 27, figs. 5, 6, 11, 12, 16, 17. (*Syn.* to 1969).

1988 ?*Trigonodus laripintinensis* (CRESPIN); WATSON, p. 129, Pl. 2, figs. 12–14, 18–20, 22, 23.

Remarks:

The damaged drepanodiform (Sd) element is erect and the anterior and the posterior costae are not clearly defined. The prominent anterior basal protrusion is evident on this element. The lateral surfaces of the cusp are convex. The elements in WATSON (1988, Pl. 2, figs. 16 and 17) are characteristic of this species and show the sharp, prominent anterior costae. The lateral costae can extend to the apex of the cusp on the anterior side of the element. The form of the element is similar to the drepanodiform element of *Drepanodus concavus*. The prominent, sharp, costate edge is not evident in the *Drepanoistodus concavus* BRANSON & MEHL element illustrated in MOUND (1968, Pl. 2, fig. 18).

Occurrence:
Only one Sd element was recovered from the Karmberg limestone within the Florentine Valley. It is a common species within the Horn Valley Siltstone, Central Australia, and the Upper Coolibah Formation within the Georgina Basin, Australia (STAIT & DRUCE 1993).

Age:
STAIT & DRUCE (op. cit.) recorded *Triangulodus larapintinensis* in a fauna that ranged in age from the Middle to Late Areneig.

Specimen:
Section KARM 7: One element.

Genus *Variabiloconus* LANDING, BARNES & STEVENS 1986
Type species: *Paltodus bassleri* FURNISH 1938.

Variabiloconus variabilis LINDSTRÖM 1955
Plate 6.19, figs. 1–6.

Synonymy:

1955 *Oneotodus variabilis* n. sp. LINDSTRÖM; p. 582, Pl. 2, figs. 14–18, 47, Pl. 5, figs. 4–5, text–fig. 6.

1993 Conical Element, Element III, STAIT & DRUCE; p. 322, fig. 22A,

1996 *"Oneotodus" variabilis* (LINDSTRÖM); LÖFGREN , fig. 8L.

The apparatus of non 1998 *Oenotodus variabilis* ALBANESI; p. 127, Pl. 5, figs. 31–32.

1999 *Variabiloconus variabilis* (LINDSTRÖM); LÖFGREN, p. 162–166, Pl. 11–20, Pl. 2, figs. 1–17, Text–fig. 2.

Remarks:
LÖFGREN et al., (1999) stated that "*Oneotodus*" *variabilis* recovered in the Baltic regions should be transferred to the genus *Variabiloconus* (LANDING et al., 1986).

The element is very similar to the Sd element illustrated in LÖFGREN et al., (1999, Pl. 1, fig. 20.) The cusp of the element is recurved. It has a rounded anterior surface and the basal cavity flares showing a pronounced straight posterobasal edge. The posterior edge has a pronounced concave surface and two prominent carinae are evident. The element illustrated in STAIT & DRUCE (1993, Fig. 22A, Element III) is very similar to the Sd elements of *Variabiloconus variabilis* found in the Karmberg Limestone and is considered to be a similar species.

Age:
LINDSTRÖM (1955) reported *Variabiloconus variabilis* as *Oneotodus variabilis* n. sp. from the *Paltodus deltifer* Zone in Baltoscandia.

Variabiloconus variabilis correlates with the *Rossodus manitouensis* Zone in Nevada. LÖFGREN et al., (1999) noted that species of *Variabiloconus variabilis* from the Missouri Gulch, Colorado and the Ninemile Canyon, Nevada of North America ranged from the *Rossodus manitouensis* Zone to the *Macerodus dianae* Zone in the Hamburg klippe region of eastern Pennsylvania.

LÖFGREN et al., (1999) also noted that *Variabiloconus variabilis* recorded in the Upper Tremadoc in the Baltic Region. This may extend the range of the species range in Tasmania.

Specimens:
Six specimens were obtained from the Karmberg Limestones.
Section KARM 4: Two Sd elements.
Section KARM 2: Two Sd elements.
Section KARM 1: One Sd element.
Section KARM 2: One Sd element.
Section KARM 10.One Sd element.

Phylum: Arthropoda

Genus *Parapilikia* KOBAYASHI 1934
Type Species: *Calymene ?speciosia* DALMAN

Parapilikia ?acucodata STAIT 1976
Plate 6.19, fig. 8.

Synonymy:

1976 *Parapilikia ?acucodata* n. sp. STAIT; p. 125, figs. A, B.

Remarks:
The fragment of the pygidium is similar to the species of *Parapilikia ?acucodata* STAIT recorded from the Florentine Valley. The pygidium is subcircular and the pleural ribs widen towards the margin. Several of the pleural ribs terminate with spines, others are damaged.

Specimen:
One a part of the pygidium recovered from the Section KARM 2.

Genus *Hystricurus* RAYMOND 1913

Type Species: *Bathyurus conicus* BILLINGS 1959

Hystricurus cf. *H. timsheaensis* STAIT 1976

Plate 6.19, fig. 9.

Type species: *Hystricurus timsheaensis* STAIT 1976

Remarks:
The pygidium was recovered from the Lower Karmberg Limestone at The Gap. The pygidium is subcircular with 5 axial rings and a short terminal lobe. The axial rings taper towards the terminal lobe. The three axial ring closest to the thorax appears to have a centrally placed pustule on their upper surface.

Specimen:
One pygidium recovered from the Section KARM 8.

Gastropod sp.

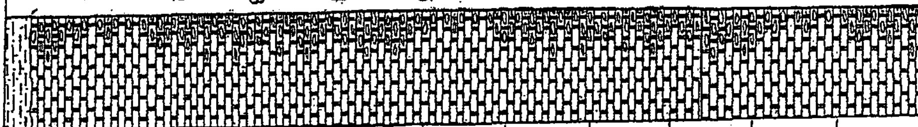
Plate 6.19, fig. 7.

An internal mould of an unknown species of gastropod from Section KARM 2.

Table 6.4. Correlation of the Karmberg Limestone with other localities within Australia and internationally on the basis of conodont faunas.

After ETHINGTON & CLARK (1971), STAIT (1976, unpub.), COOPER (1981), MCTAVISH (1973), SERPAGLI (1974), BURRETT (1978, unpub.), REPETSKI (1982), AN et al., (1985), WATSON (1988), STAIT & DRUCE (1994), POHLER (1994), SEO et al., (1994), LEHNERT (1995a), JI & BARNES (1996) and ALBANESI (1998b).

Estimated thickness 40m



Conodont Species	Florentine Valley Fm.	KARM 1	KARM 2	KARM 3	KARM 4	KARM 5	KARM 6	KARM 7	KARM 8	KARM 9	KARM 10
Acanthodus lineatus					●						
Acodus russoi			●		●						
Acontiodus iowensis								●			●
Appalachignathus sp.?											
Aurilobodus leptosomatus?							●	●	●		
Aurilobodus sp.											
Bergstroemognathus extensus		●					●		●		
Cornuodus longibasis			●		●	●	●	●	●	●	
Dapsilodus sp. cf. *D. mutatus*									●		
Drepanodus arcuatus					●						
Drepanodus homocurvatus		●				●	●				
Drepanodus parallelus			●				●				
Drepanodus sp.											
Drep[anoistodus basiovalis			●		●						
Drepanoistodus forceps		●	●	●	●	●	●	●	●		
Erismodus gracilis							●				
Glyptoconus quadriplicatus						●					
Juanognathodus jaanussoni						●	●				
Juanognathodus variabilis		●	●		●	●	●		●		
Jumodontus gananda									●		
Oepikodus communis							●				
Oepikodus evae											●
Oepikodus sp.									●		●
Oistodus hunickeni							●				
Oistodus cf. *lanceolatus*								●			●
Oneotodus ?gracilis							●	●	●		
Teridontus nakamurai					●		●		●		
Paltodus sweeti			●				●		●	●	
Paraprioniodus sp.			●								
Polonodus sp.		●					●		●		
Protopanderodus elongatus		●	●		●		●		●	●	●
Protopanderodus gradatus					●	●	●	●		●	
Protopanderodus cf. *P. leei*					●						
Protopanderodus cf. *primitus*							●			●	
Protopanderodus rectus									●		●
Protopanderodus sp.											
Protopanderodus varicostatus ?					●						
Pteracontiodus cryptodens									●		
Reutterodus andinus							●			●	
Rossodus manitouensis			●	●	●	●	●		●		
Scalpellodus tersus					●		●		●		●
Scandodus americanus									●		
Scandodus brevibasis											●
Scandodus furnishi									●		
Scandodus sp.					●		●				
Scolopodus filosus			●		●		●				●
Scolopodus floweri									●		
Scolopodus giganteus										●	
Scolopodus krummi			●	●	●	●	●	●	●		●
Scolopodus rex					●	●	●	●	●		●
Semiacontiodus cornuformis							●				
Stolodus sp. aff. *S. stola*. ?							●				
Tasmanognathus sp.		●									
Triangulodus cf. *T. brevibasis*			●				●	●	●		
Triangulodus larapintinensis								●			
Variabiloconus variabilis		●	●		●						●
Trilobites											
?Parapileka acutodata			●								
Hystericurus cf. *timsheaensis*									●		

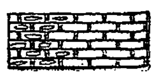
Section Intervals

Kamberg Limestone.

<table>
<tr><th></th><th>Conodont Zonation not to Scale.</th><th>North American Mid Continent Fauna ETHINGTON & CLARK (1974).</th><th>Argentina Conodont Fauna SERPAGLI (1974).</th></tr>
<tr><td rowspan="9">ORDOVICIAN</td><td>M. parva</td><td rowspan="3"></td><td rowspan="2">Fauna D.
Drepanoistodus forceps.</td></tr>
<tr><td>P. originalis</td></tr>
<tr><td>P. navis</td><td rowspan="2">Fauna C.
Reutterodus andinus n. sp.
D. arcuatus
P. (O.) evae
Cornuodus longibasis</td></tr>
<tr><td>P. triangularis</td><td rowspan="3">Fauna E = Oepikodus communis Zone
Oepikodus communis ETHINGTON & CLARK
Scandodus cf. furnishi
Pteracontiodus cryptodens MOUND.
Juanognathodus variabilis SERPAGLI
Reutterodus andinus SERPAGLI
Glyptoconus quadriplicatus BRANSON & MEHL.
Protopanderodus gradatus SERPAGLI
Jumudontus gananda COOPER
Bergstroemognathodus extensis SERPAGLI
Fauna E show greater faunal diversity and more environmental partitioning.</td></tr>
<tr><td>O. evae</td><td>Fauna B
Acodus ? russoi n. sp.
Scolopodus rex n. sp.
Juanognathodus variabilis n. sp.
Oistodus hunickeni n. sp.</td></tr>
<tr><td>P. elegans</td><td rowspan="2">Fauna A.
Scandodus cf. furnishi
Paltodus ? sweeti n. sp.
Scandodus americanus n. sp.
Bergstroemognathus extensus
Reutterodus andinus n. sp.
Drepanodus arcuatus
Drepanoistodus forceps.</td></tr>
<tr><td>P. proteus</td><td rowspan="2">Fauna D. ETHINGTON & REPETSKI (1984).
Glyptoconus quadriplicatus BRANSON & MEHL
Oneotodus sp.
Protopanderodus elongatus SERPAGLI
Oepikodus communis ETHINGTON & CLARK
Drepanodus arcuatus PANDER
Scolopodus rex, LINDSTRÖM
Cornuodus longibasis LINDSTRÖM</td></tr>
<tr><td>D. deltifer</td><td rowspan="2"></td></tr>
<tr><td>C. angulatus</td><td>Fauna C. ETHINGTON & REPETSKI (1984).
"Acontiodus" iowensis FURNISH
Rossodus manitouensis REPETSKI & ETHINGTON
"Acanthodus" lineatus FURNISH</td></tr>
</table>

Table 6.5. A comparison of the Conodont Zonation of the North American Mid Continent Fauna of ETHINGTON & CLARK (1974) and the Argentine conodont fauna of SERPAGLI (1974). Both faunas have similar species to the Tasmanian Karmberg Lower to Middle Ordovician conodont faunas.

Key

 Karmberg Limestone. (Ordovician)

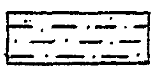
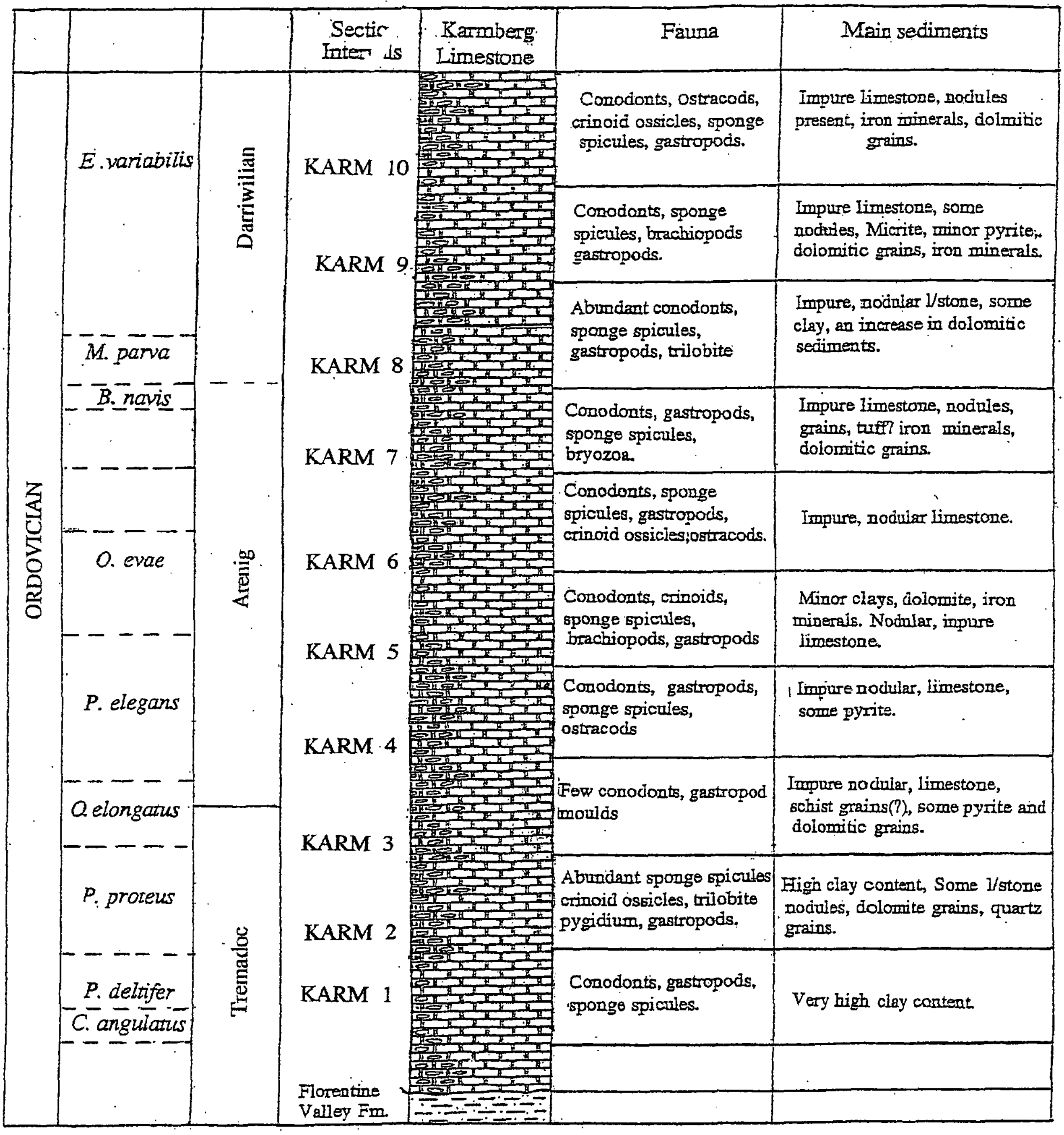
 Florentine Valley Formation. (Ordovician).

Table 6.6. Table showing the stratigraphic section taken from the basal region of the Karmberg Limestone (in contact with the Florentine Valley Formation) at the Gap, Florentine Valley, Tasmania.

The section is not to scale as a continuous section was impossible to obtain due to the thickness of the vegetation cover.

Estimated thickness 40m



A stratigraphic column of the Karmberg Limestone at the Gap showing the sample sites, the main fauna encountered, the lithology and a tentative conodont zonation based upon the sites which produced the most conodont specimens.

In some sections too few conodonts were recovered to accurately establish conodont zones within the Karmberg Limestone.
Estimated thickness 40m

Table 6.7. The distribution of the types of conodont elements from the Karmberg Limestone, Tasmania

Conodont Species	Type of Element	Sections taken through the Lower Karmberg Limestones: 1	2	3	4	4.1	4.2	5	6	7	7.1	8	9	10	Total
Acanathodus lineatus	Sa				1										1
Diaphorodus russoi	Sa		1		1										2
Acontiodus iowensis								1							1
Appalachignathus sp.														2	2
Aphelognathus sp. cf *politis*			1												1
Aurilobodus sp.														2	2
Aurilobodus ?leptosomatus									1	1		1			3
Bergstroemongnathus	Pb	1						1							2
extensus	Sa											1			1
Cornuodus longibasis	Pb									1					1
	Sa							1	1						2
	Sb		1					1					1		3
	Sc				1							1			2
	Sd		2									1			3
	S				2				1						3
Dapsilodus mutatus	Sc											1			1
Drepanodus arcuatus					1										1
Drepanodus homocurvatus	S	1						1	1						3
Drepanodus parallelus	Sa									1					1
	Sd		1												1
Drepanoistodus	S		1												1
basiovalis	M				1										1
Drepanoistodus forceps	Sa									1					1
	Sc		1		1?			2	3			3+1?			11
	Sd	1		1	1										3
	P									1					1
Erismodus gracilis							2								2
Glyptoconus quadriplicatus	*a*							1							1
Juanognathodus	*a*							1							1
jaanussoni	*c*							1							1
	e							1	1+1?						3
Juanognathodus variabilis	*a*	1	2					1				1			5
	b	1													1
	c				1										1
	e								1						1
Jumudontus gananda	Pa											1			1
Oepikodus communis	M								1						1
Oepikodus evae	M													1	1
Oepikodus sp.	M											1		1	2
"*Oistodus*" *hunickeni*	S								1						1
Oistodus cf. *lanceolatus*	M									1				1	2
Teridontus cf. *T. nakamurai*	*a*				3+1?				2			1			7
"*Oneotodus*" *gracilis*									1	1		1			3
Paltodus sweeti	Sa											1			1
	Sb		1												1
	Sc												1		1
	M								1						1
Paraprioniodus sp.			1												1
Polonodus sp. A.		1							1			1			3
Protopanderodus elongatus	*a-b*		1			1			3				1	1	7
	c	1													1
	e											1?		1	2
	f								1						1
Total		7	13	1	14	1	2	12	21	7		17	3	9	107

Protopanderodus gradatus	*a-b*				2										2
	c				3					1		1	1		6
	e							1	3	1				1	6
	f								2						2
Protopanderodus leei	Sc				1										1
P. cf. *P. primitus*	Sb								1						1
Protopanderodus rectus	Sb											1		1	2
Protopanderodus Varicostatus					1										1
Pteracontiodus cryptodens												1			1
Reutterodus andinus	Sb								2						2
	M								1				1		2
Rossodus manitouensis	*a*		1												1
	b			1				1	1			2			5
	e				2							2			4
Scalpellodus tersus	Pa				1									1	2
	Sb													2	2
	Sc				3									1	4
	Sd								1			1			2
Scalpellodus sp.	Sa				1										1
cf. *S. tersus*	Sb								1						1
Scandodus americanus	M											1			1
Scandodus sp.	Sb													1	1
Scolopodus filosus	Sd?		1												1
					3										3
									1					1	2
Scandodus furnishi												1			1
Scolopodus floweri												1			1
Scolopodus giganteus													1		1
Scolopodus krummi	*a*	1								1		1			3
	b											1			1
	c				2							1			3
	f								1						1
Scolopodus rex	*a*				3			1?	1	1		1			6+1?
	b				2				1						3
	e							1							1
	f								1	1					2
Scolopodus sp. cf. *S. rex*	*e*													1	1
Semiacontiodus	Sd								1						1
cornuformis									1						1
Stolodus sp. *S. stola*								1							1
Tasmanognathodus sp.	Sa	1													1
Teridontus nakamurai	P									1					1
	S				1										1
	Sc				1										1
Triangulodus cf.	Sa				1										1
T. brevibasis	Sc				1				1	1		1			4
Trinagulodus										1					1
larapintinenesis										1					1
Variabiliconus variabilis	Sd	1	3		2									1	7
Totals:		10	18	2	44	1	2	17	41	16	33	6		19	209
Trilobites Species	Element	1	2	3	4	4.1	4.2	5	6	7	7.1	8	9	10	Total
Parapilikia															
?*acucodata*	pygidium		1												1
Hystricurus cf.															
H. timsheaensis	pygidium											1			1
Total			1									1			2

All conodont elements are from samples taken from the Karmberg Limestone in the Florentine Valley west of Maydena, central southern Tasmania.

Plate 6.1.

Figs. 1–2. *Diaphorodus russoi* SERPAGLI.

Fig. 1. Postero–lateral view of the element. trichonodelliform (Sa) element.
Sample KARM 2, X80 TUGD128340

Fig. 2. Postero–lateral basal view of atrichonodelliform (Sa) element.
Sample KARM 4, X100. TUGD128341

Figs. 3–4. *Aurilobodus leptosomatus* ? XIANG & ZHANG.

Fig. 3. Postero-lateral view of element. Sample KARM 6, X 115. TUGD128342

Fig. 4. Postero–lateral view of element. Sample KARM 7, X175. TUGD128343

Fig. 5. *Aurilobodus* sp.? XIANG & ZHANG. Posterior view of element.
Sample KARM 10, X175. TUGD128344

Fig. 6. *Appalachignathus leptosomatus* ? BERGSTRÖM. Damaged element and encrusted with crystallites. Sample KARM 10, X85. TUGD128345

Fig. 7. *Appalachignathus* ? sp. Lateral view of a spathognathiform element. Sample KARM 10, X175. TUGD128346

Fig. 8. *Acontiodus iowensis* FURNISH. Posteriobasal view of element.
Sample KARM 7, X125. TUGD128347

Fig. 9–11. ?*Bergstroemognathus extensus* GRAVES & ELLISON.

Fig. 9. Lateral view of a fragment of an ?Pa element.
Sample KARM 3, X115. TUGD128348

Fig. 10. Lateral view of a Pb element. Sample KARM 1, X75. TUGD128349

Fig. 11. Lateral view of a Pb element. Sample KARM 8, X95. TUGD128350

Fig. 12. *Dapsilodus* sp. cf. *Dapsilodus mutatus* BRANSON & MEHL.
Lateral view of a damaged element. Sample KARM 8, X135. TUGD128351


Plate 1.
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Plate 1.
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Plate 6.2.

Figs. 1–12. *Cornuodus longibasis* LINDSTRÖM.

Fig. 1. Lateral view of an Sa element. Sample KARM 5 X165.	TUGD128352
Fig. 2.. Lateral view of an Sd element. Sample KARM 1, X115.	TUGD128353
Fig. 3. Lateral view of an Sd element. Sample KARM 4, X80.	TUGD128354
Fig. 4. Lateral view of an Sb element. Sample KARM 1, X80.	TUGD128355
Fig. 5. Lateral view of an S ? element. Sample KARM 4, X 90.	TUGD128356
Fig. 6. Lateral view of an Sa element. Sample KARM 6, X90.	TUGD128357
Fig. 7. Lateral view of an Sb element. Sample KARM 2, X90.	TUGD128358
Fig. 8. Lateral view of an S? element. Sample KARM 6, X120.	TUGD128359
Fig. 9. Lateral view of an Sc element. Sample KARM 8, X100.	TUGD128360
Fig. 10. Lateral view of a damaged S element. Sample KARM 4, X135.	TUGD128361
Fig. 11. Lateral view of an Sd element. Sample KARM 4, X110.	TUGD128362
Fig. 12. Lateral view of an Sd element. Sample KARM 4, X100.	TUGD128363


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Plate 6.3.

Figs. 1–2. *Drepanoistodus forceps* LINDSTRÖM.

Fig. 1. Lateral view of an *e* element. Sample KARM 10, X230. TUGD128364

Fig. 2. Lateral view of a damaged *e* element.Sample KARM 10, X200. TUGD128365

Fig. 3. *Drepanodus* sp.

Fig. 3. Lateral view of an *a* element. Section KARM 7, X200. TUGD128366

Figs. 4–7. *Drepanoistodus forceps* LINDSTRÖM.

Fig. 4. Lateral view of an Sa element. Sample KARM 7, X220 TUGD128367

Fig. 5. Lateral view of a reclined Sd element. Sample KARM 6, X190. TUGD128368

Fig. 6. Lateral view of a reclined Sd element. Sample KARM 4, X 150. TUGD128369

Fig. 7. Lateral view of an Sd element. Sample KARM 5, X80. TUGD128370

Figs. 8–10. *Drepanodus homocurvatus* LINDSTRÖM.

Fig. 8. Lateral view of an S element. Sample KARM 1, X130. TUGD128371

Fig. 9. Lateral view of an S element. Sample KARM 5, X170. TUGD128372

Fig. 10.Lateral view oif an Sd element. Sample KARM 6, X80. TUGD128373

Figs. 11–12. *Drepanodus parallelus* BRANSON & MEHL.

Fig. 11. Sd element. Sample KARM 2, X85. TUGD128374

Fig. 12. Sa element. Sample KARM 6, X135. TUGD128375

Figs. 13–14. *Erismodus gracilis* BRANSON & MEHL.

Fig. 13. Damaged and crystallite encrusted cusp? of an element.
Sample KARM 6, X115. TUGD128376

Fig.14. Damaged element. Sample KARM 6, X120. TUGD128377

Plate 3.

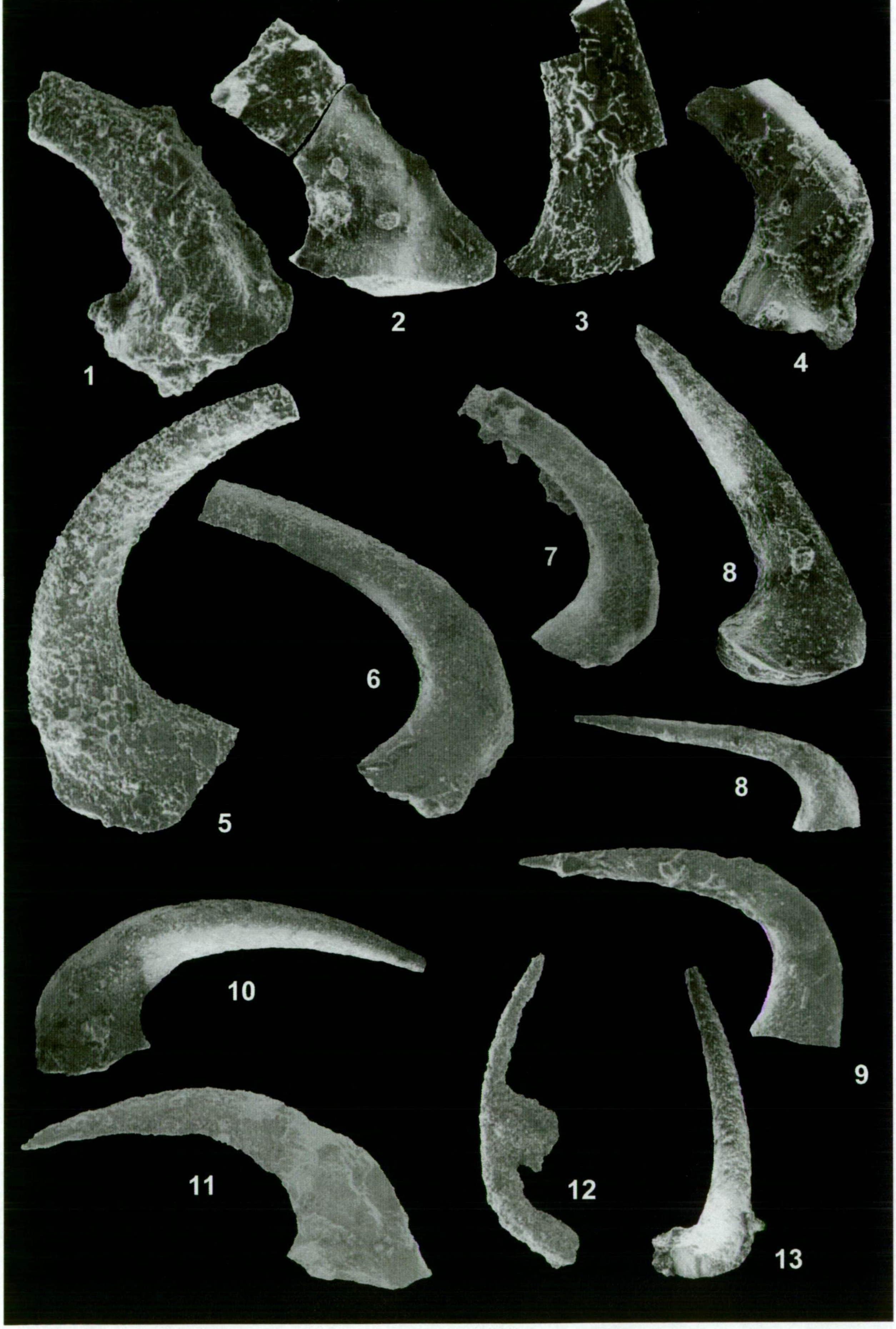

Plate 6.4.

Fig. 1. *Drepanodus forceps* LINDSTRÖM.

Lateral view of an Sc element. Sample KARM 5, X125. TUGD128378

Fig. 2. *Drepanodus* sp. cf. *forceps* LINDSTRÖM.

Lateral view of an Sc element. Sample KARM 6, X110. TUGD128379

Fig. 3–7. *Drepanoistodus forceps* LINDSTRÖM.

Fig. 3. Lateral view of a recurved Sd element. Sample KARM 4, X130. TUGD128380

Fig. 4. Lateral view of an Sc element. Sample KARM 6, X 145. TUGD128381

Fig. 5. Lateral view of an Sd element. Sample KARM 4, X95. TUGD128382

Fig. 6. Lateral view of an Sc element. Sample KARM 5, X100. TUGD128383

Fig. 7. Lateral view of an Sc element. TUGD128384

Fig. 8. *Drepanoistodus basiovalis* SERGEEVA. Lateral view of a P? element. Sample KARM 7, X100. TUGD128385

Fig. 9. ? *Drepanoistodus forceps* LINDSTRÖM. Lateral view of a damaged Sd element. Sample KARM 3, X90. TUGD128386

Fig. 10. *Drepanoistodus basiovalis* SERGEEVA Lateral view of an Sc element. Sample KARM 8, X105. TUGD128387

Fig. 11. *Drepanoistodus ?forceps* LINDSTRÖM. Lateral view of an ?Sb element. Sample KARM 4, X155. TUGD128388

Fig. 12. *Drepanoistodus ?forceps* LINDSTRÖM. Lateral view of an ?Sb element. Sample KARM 8, X120. TUGD128389

Plate 4.

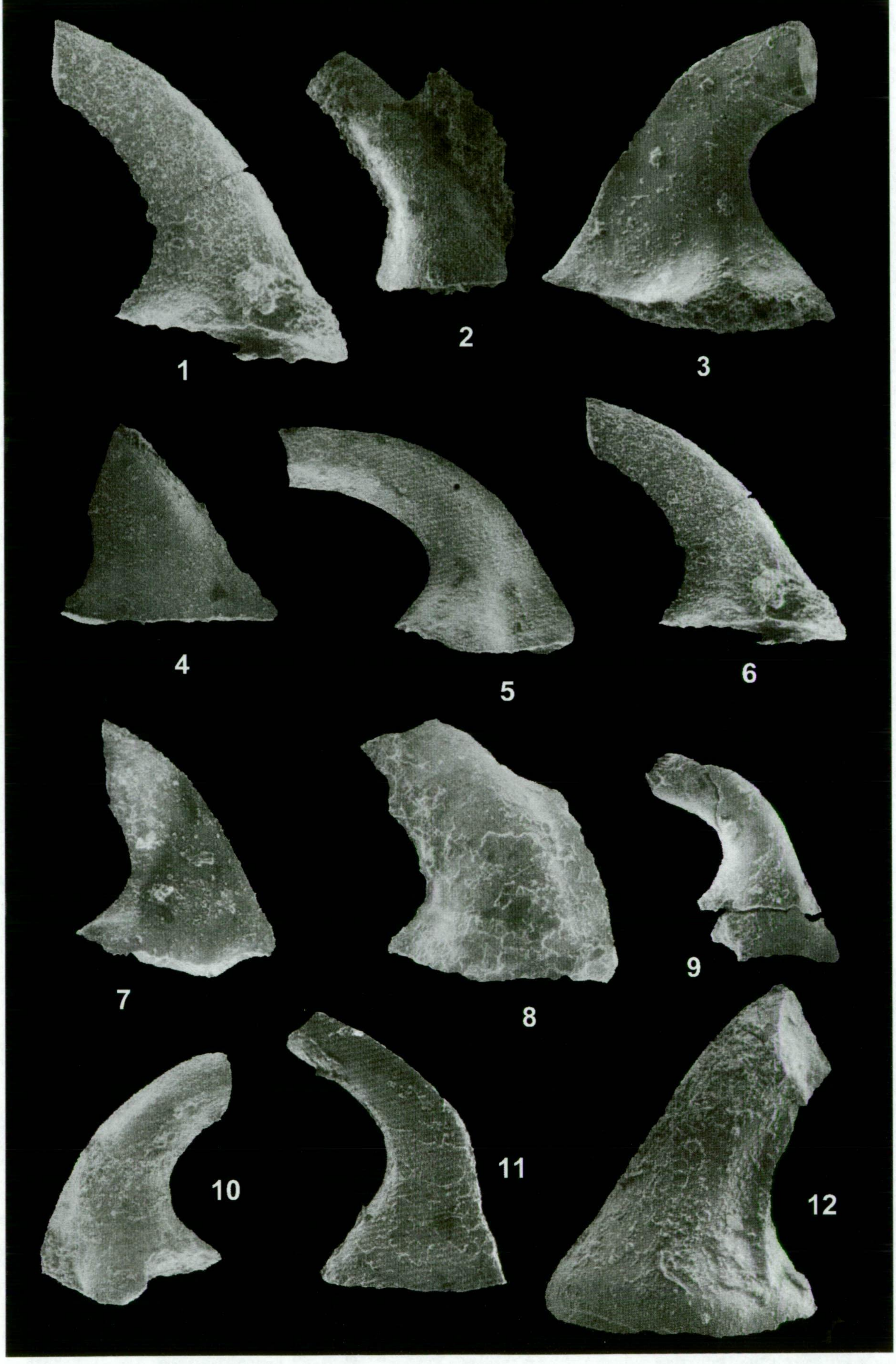

Plate 6.5.

Fig. 1. *Drepanoistodus forceps* LINDSTRÖM. Lateral view of an Sa element.
Sample KARM 7 X115. TUGD128390

Fig. 2. *Drepanoistodus* sp. cf. *D. forceps* LINDSTRÖM. Lateral view of an Sd element.
Sample KARM 2, X150. TUGD128391

Fig. 3. *Drepanoistodus forceps* LINDSTRÖM. Lateral view of a Sd element.
Sample KARM 4, X105. TUGD128392

Fig. 4. *Drepanoistodus forceps* LINDSTRÖM. Lateral view of an Sc element.
Sample KARM 6, X105. TUGD128393

Figs. 5-9. The classification of elements of *Juanognathus jaanussoni* SERPAGLI (1974) is the same as that proposed by ALBANESI (1998b, p. 125.)

Fig. 5. Posterolatertal view of a *c* element. Sample KARM 6, X100. TUGD128394

Fig. 6. Posterolateral view of an *e* element. Sample KARM 6, X115. TUGD128395

Fig. 7. Posterior view of a damaged ? *e*element. Sample KARM 6, X125. TUGD128396

Fig. 8. Posterior view of a damaged *e* element. Sample KARM 5, X105. TUGD128397

Fig. 9. Posterolateral view of an *a* element. Sample KARM 5, X 130. TUGD128398

Plate 5.

Plate 6.6.

All elements of *Juanognathus variabilis* SERPAGLI (1974) and *Juanognathus jaanussoni* SERPAGLI (1974) are classified using the Assemblage Plan of ALBANESI (1998b, Pl. 5, figs. 10–14).

Figs. 1–9. *Juanognathus variabilis* SERPAGLI (1974).

Fig. 1. Posterolateral view of an *a* element. Sample KARM 6, X100. TUGD128399

Fig. 2. Posterolateral view of an *a* element. Sample KARM 8, X165. TUGD128400

Fig. 3. Postero–lateral view of a *c* element. Sample KARM 4, X80. TUGD128401

Fig. 4. Postero–lateral view of an *a* element. Sample KARM 2, X185. TUGD128402

Fig. 5. Posterior view of a damaged *a* element. Sample KARM 5, X130. TUGD128403

Fig. 6. Posterior view of a damaged *a* element. Sample KARM 1, X90. TUGD128404

Fig. 7. *Juanognathus ?variabilis* SERPAGLI. (1974).

Fig. 7. Posterior view of an *a* damaged element. Sample KARM 1 X85. TUGD128405

Figs. 8, 9. *Juanognathus variabilis* SERPAGLI (1974).

Fig. 8. Anterior view of an *a* element. Sample KARM 5, X90? TUGD128406

Fig. 9. Posterior view of the *a* element in Fig. 8. Sample KARM 5, X100 TUGD128407

Fig. 10. *Glyptoconus quadraplicatus* BRANSON & MEHL.

Fig. 10. Posterolateral view of an *a* element. Sample KARM 5, X90? TUGD128408


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Plate 6.7.

Fig. 1. *Jumudontus gananda* COOPER. Fragment of a Pa element.
Section KARM 8, X20 TUGD128409

Fig. 2. *Oepikodus communis* ETHINGTON & CLARK. Lateral view.
of an M element. Sample KARM 6, X90. TUGD128410

Fig. 3. *Oepikodus* sp. Lateral view of an M element. Sample KARM 10, X125.
TUGD128411

Fig. 4. *Oepikodus* sp. Lateral view of an M element. Sample KARM 8, X120. TUGD128412

Fig. 5. *Oistodus hunickeni* SERPAGLI. Lateral view of an (S) element.
Sample KARM 6, X130. TUGD128413

Fig. 6. *Oistodus lanceolatus* PANDER.
Fig. 6. Lateral view of an Sc element. Sample KARM 7, X115. TUGD128414
Fig. 7. Lateral view of element. Sample KARM 10, X145. TUGD128415

Figs. 8 –11. *Paltodus sweeti* SERPAGLI.
Fig. 8. *Paltodus sweeti* SERPAGLI. Lateral view of an Sc element.
Sample KARM 9, X120. TUGD128416
Fig. 9. *Paltodus sweeti* SERPAGLI. Lateral view of an Sb element.
Sample KARM 2, X85. TUGD128417
Fig. 10. *Paltodus sweeti* SERPAGLI. Lateral view of an Sa element.
Sample KARM 8, X110. TUGD128418
Fig.11. *Paltodus sweeti* SERPAGLI. Lateral view of an M element.
Sample KARM 6, X95. TUGD128419

Fig. 12. *Oepikodus evae* LINDSTRÖM.
Fig. 12. Lateral view of a cusp of an element. Sample KARM 6, X120. TUGD128420

Plate 7.

Plate 6.8.

Elements of *Protopanderodus elongatus* SERPAGLI have been classified by using the assemblage described in: ALBANESI (1998b, p. 127, Text–fig. 14, D.)

Fig. 1–8. *Protopanderodus elongatus* SERPAGLI.

Fig. 1. *Protopanderodus elongatus* SERPAGLI. Lateral view of an *e* element. Sample KARM 10, X125. TUGD128421

Fig. 2. Lateral view of a damaged ?*e* element. Sample KARM 8, X150. TUGD128422

Fig. 3. Lateral view of a damaged *a–b* element. Sample KARM 6, X95. TUGD128423

Fig. 4. Lateral view of an *a–b* element. Sample KARM 6, X100. TUGD128424

Fig. 5. Lateral view of a damaged *a–b* element. Sample KARM 4, X80. TUGD128425

Fig. 6. Lateral view of an *a–b* element. Sample KARM 10, X40. TUGD128426

Fig. 7. Lateral view of a damaged *a–b* element. The size and orientation of the basal cavity is shown in the longitudinal view. TUGD128427

Fig. 8. *Protopanderodus elongatus* SERPAGLI.
Lateral view of a *c* element. Sample KARM 1, X150. TUGD128428
The lateral costate is straighter in this form of the element.
(See ALBANESI 1998b, Text–fig. 14, fig. D, element c).

Fig. 9. *Protopanderodus elongatus* SERPAGLI. Lateral view of an *f* element. Sample KARM 6, X210. TUGD128429

Fig. 10. *Protopanderodus elongatus* SERPAGLI. Lateral view of an *a–b* element. Sample KARM 9, X90. TUGD128430

Fig. 11. *Protopanderodus elongatus* SERPAGLI. Lateral view of an *a–b* element. Sample KARM 6, X125. TUGD128431

Fig. 12. *Protopanderodus* cf. *gradatus* SERPAGLI. Lateral view of a *c* element. Sample KARM 6, X130. TUGD128432

Fig. 13. *Protopanderodus* cf. *gradatus* SERPAGLI. Lateral view of a *c* element. Sample KARM 5, X80. TUGD128433

Plate 8.

Plate 6.9.

Figs. 1–13. *Protopanderodus gradatus* SERPAGLI.

Fig. 1. Lateral view of an *e* element. Sample KARM 6, X160. TUGD128434

Fig. 2. Lateral view of an *e* element. Sample KARM 5, X210. TUGD128435

Fig. 3. Lateral view of an *e* element. Sample KARM 9, X185. TUGD128436

Fig.4. Lateral view of an *e* element. Sample KARM 6, X225. TUGD128437

Fig. 5. Lateral view of an *e* element. Sample KARM 4, X185. TUGD128438

Fig. 6. Lateral view of an *e* element. Sample KARM 6, X155. TUGD128439

Fig. 7. Lateral view of a *c* element. Sample KARM 4, X180. TUGD128440

Fig. 8. Lateral view of a *c* element. Sample KARM 4, X120. TUGD128441

Fig. 9. Lateral view of a damaged *c* element. Sample KARM 9, X185. TUGD128442

Fig. 10. Lateral view of an ?*a–b* element. Sample KARM 4, X125. TUGD128443

Fig. 11. Lateral view of an *f* element. Sample KARM 6, X 160. TUGD128444

Fig.12. Lateral view of a damaged *e* element. Sample KARM 7, X160. TUGD128445

Fig. 13. Lateral view of a *c* element. Sample KARM 8, X170. TUGD128446

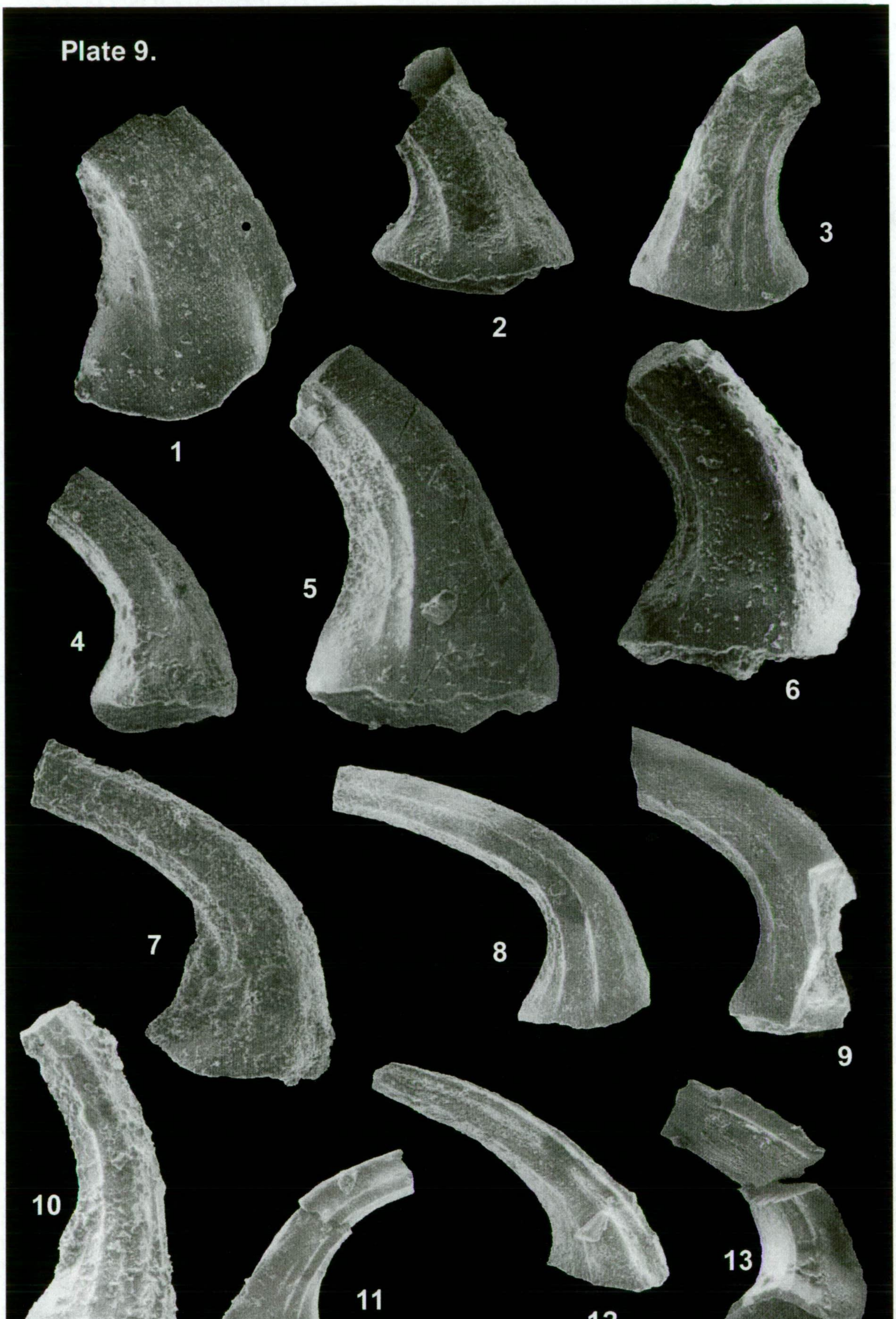

Plate 9.

Plate 6.10.

Fig. 1-3. *Oneotodus nakamuri* ? NOGAMI (1967).

Fig. 1. Lateral view of an *a* element. Sample KARM 6, X115. TUGD128447

Fig. 2. Lateral view on an *a* element. Sample KARM 6, X145. TUGD128448

Fig. 3. Lateral view on an *a* element. Sample KARM 8, X75. TUGD128449

Fig. 4. *Oneotodus ?gracilis* FURNISH (1938).

Fig. 4. Lateral view on an *a* element. Sample KARM 8, X80. TUGD128450

Figs. 5, 6.*Oneotodus nakamuri* ? NOGAMI (1967).

Fig. 5. Lateral view of an *a* element. Sample KARM 7, X100. TUGD128451

Fig. 6. Lateral view of an *a* element. Sample KARM 7, X105. TUGD128452

Figs. 7, 8. *Oneotodus ?gracilis* FURNISH (1938).

Fig. 7. Lateral view of an *a* element. Sample KARM ? X115. TUGD128453

Fig. 8. Lateral view of an *e* ? element. Sample KARM ? X100? TUGD128454

Figs. 9, 10, 11. *Oneotodus nakamuri* ? NOGAMI (1967).

Fig. 9. Lateral view of an *a* element. Sample KARM 4, X 100. TUGD128455

Fig. 10. Latetal view of a damaged *a* element. Sample KARM 4, X125. TUGD128456

Fig. 11. Lateral view of an *a* element. Sample KARM 4, X105. TUGD128457

Fig. 12. *Scolopodus floweri* REPETSKI. Lateral view of element. Sample KARM 7, X100. TUGD128458

Fig 13. *Scandodus furnishi* LINDSTRÖM. Lateral view of element. Sample KARM 8, X125. TUGD128459

Fig. 14. *Protopanderodus rectus* ? LINDSTRÖM. Lateral view of cusp of an acodontiform (Sc) element. Sample KARM 10, X105. TUGD128460


Plate 10.
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Plate 6.11.

Fig. 1. *Paraprioniodus* sp. Lateral view of element. Sample KARM 2, X90. TUGD1284661

Fig. 2. *Protopanderodus* cf. *primitus* COOPER (1981). Lateral view of the element.
Sample KARM 6, X85. TUGD128463

Fig. 3. *Acanthodus lineatus* FURNISH. Lateral view of an Sa (*e*) element.
Sample KARM 4, X125. TUGD128463

Figs. 4, 5. *Protopanderodus* cf. *primitus* COOPER (1981).
Fig. 4. Lateral view of element. Sample KARM 6, X180. TUGD128464
Fig. 5. *Protopanderodus* cf. *primitus* COOPER (1981).
Sample KARM 9, X140. TUGD128465

Fig. 6-7. *Protopanderodus gradatus* SERPAGLI.
Fig. 6. Lateral view of a *c* element. Sample KARM 7, X140. TUGD128466
Fig. 7. Lateral view of a *c* element. Sample KARM 4, X145. TUGD128467

Fig. 8. *Pteracontiodus cryptodens* MOUND. Oblique posterolateral view of element
Sample KARM 8, X125. TUGD128468

Figs. 9–11. ?*Polonodus* sp.
Fig. 9. ?*Polonodus* sp. Oral view of an element.
Sample KARM 1, X110. TUGD128469
Fig. 10. ?*Polonodus* sp. Oral view of a possible P element.
Sample KARM 8, X110. TUGD128470
Fig. 11. ?*Polonodus* sp. Oral view of a possible Pa–1 element.
Sample KARM 6, X130. TUGD128471


Plate 11.
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Plate 6.12.

Figs. 1–11. *Rossodus manitouensis* REPETSKI & ETHINGTON.

The classification of the form of the elements is taken from JI & BARNES (1991, Fig. 13, Nos. 13, 16–18) and ALBANESI (1998b, p. 167, Text–fig. 29).

Fig. 1. Lateral view of a *b* element. Sample KARM 4, X170.	TUGD128472
Fig. 2. Lateral view of a *b* element. Sample KARM 6, X175.	TUGD128473
Fig. 3. Lateral view of an *a* element. Sample KARM 2, X95.	TUGD128474
Fig. 4. Lateral view of a *b* element. Sample KARM 4, X190.	TUGD128475
Fig. 5. Lateral view of a *b* element. Sample KARM 8, X125.	TUGD128476
Fig. 6. Lateral view of a *b* element. Sample KARM 4, X215.	TUGD128477
Fig. 7. Lateral view of a *b* element. Sample KARM 4, X95.	TUGD128478
Fig. 8. Lateral view of an *e* element. Sample KARM 4, X 160.	TUGD128479
Fig. 9. Lateral view of a *b* element. Sample KARM 4, X130.	TUGD128480
Fig. 10. Posteriolateral view of a *b* element. Sample KARM 8, X140.	TUGD128481
Fig. 11. Lateral view of a *c* ? element. Sample KARM 8, X85.	TUGD128482

Plate 12.

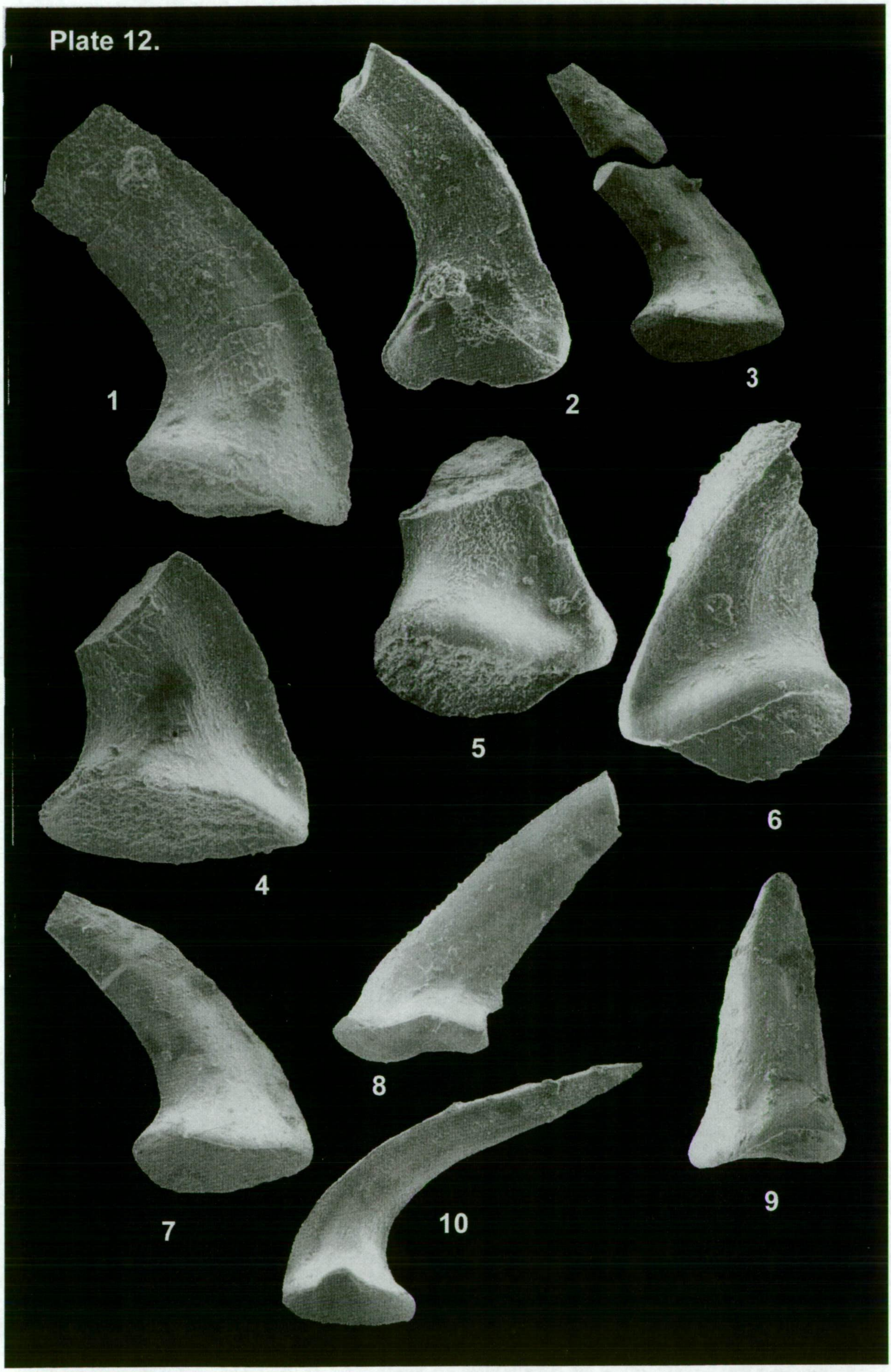

Plate 6.13.

Fig. 1. ?*Tasmanognathodus careyi* Posterior view of a trichellodontiform (Sa) element. Sample KARM 1, X95. TUGD128483

Figs. 2, 3, 4–5. *Reutterodus andinus* SERPAGLI.

Fig. 2. Lateral view of an M element. Sample KARM 9, X105. TUGD128484

Fig. 3. Lateral view of an M element. Sample KARM 6, X90. TUGD128485

Fig. 4. Oblique lateral view of an Sb element. Sample KARM 6, X130. TUGD128486

Fig. 5. Oblique lateral view of an Sb element Section KARM 6, X95. TUGD128487

Fig. 6. *Scandodus armericanus* SERPAGLI. Lateral view of an M element. Sample KARM 8, X105. TUGD128488

Fig. 7. *Protopanderodus* ? sp. Basal view of element. Sample KARM 2, X125. TUGD128489

Fig. 8. *Scandodus furnishi* LINDSTRÖM. Lateral view of element. Sample KARM 10, X210. TUGD128490

Fig. 9. *Sccalpellodus* sp. cf. *S. tersus*. Lateral view of an Sb element. Sample KARM 6, X125. TUGD128491

Fig. 10. *Protopanderodus* sp.? cf. *P. leei* REPETSKI. Lateral view of an acodontiform (Sc) element. Sample KARM 4, X100. TUGD128492

Plate 13.

Plate 6.14.

Figs. 1–9. *Scalpellodus tersus* ZHANG. In: AN et al., (1983).

Fig.1. Lateral view of a Pa element. Sample KARM 4, X110.	TUGD128493
Fig. 2. Lateral view of a Pa element. Sample KARM 10, X105.	TUGD128494
Fig. 3. Lateral view of an Sc element. Sample KARM 8, X90.	TUGD128495
Fig. 4. Lateral view of an Sc element. Sample KARM 4, X110.	TUGD128496
Fig. 5. Lateral view of an Sc element. Sample KARM 4, X100.	TUGD128497
Fig. 6. Lateral view of an Sb element. Sample KARM 10, X105.	TUGD128498
Fig. 7. Lateral view of an Sd element. Sample KARM 6, X 100.	TUGD128499
Fig. 8. Lateral view of an Sb element. Sample KARM 8, X95.	TUGD128500
Fig. 9. Lateral view of an Sb element. Sample KARM 10, X95.	TUGD128501
Fig. 10. Lateral view of an Sc element. Sample KARM 4, X100.	TUGD128502

Plate 14.

Plate 6.15.

Figs. 1–4. *Scolopodus filosus* ETHINGTON & CLARK.

Fig. 1. Posterior view of an *a* element. Sample KARM 4, X170. TUGD128503

Fig. 2. Postero–lateral view of an *a* element. Sample KARM 4, X170. TUGD128504

Fig. 3. Oblique postero–lateral view of a *b* element.

Sample KARM 4, X160. TUGD128505

Fig. 4. Oblique postero–lateral view of a ?*b* element. The basal region indicates a thick basal wall. Sample KARM 6, X110. TUGD128506

Fig. 5. *Scolopodus* sp. aff. *Scolopodus filosus* ETHINGTON & CLARK

Fig. 5. Lateral view of a *b* element. Sample KARM 10, X115, TUGD128507

Figs. 6-8. *Teridontus nakamurai* NOGAMI 1967.

Fig. 6. Lateral view of a damaged *b* element. Sample KARM 4, X110. TUGD128508

Fig. 7. Lateral view of a *c* element. Sample KARM 7, X100. TUGD128509

Fig. 8. Lateral view of a *c* element. Sample KARM 4, X95. TUGD128510

Fig. 9. *Scolopodus floweri* REPETSKI.

Fig. 9. Lateral view of an *a* element. Sample KARM 8? X110. TUGD128511

Fig. 10. *Scolopodus giganteus* SWEET & BERGSTRÖM .

Fig. 10. Lateral view of the base of an *e* element.

Sample KARM 9, X65. TUGD128512

Plate 15.

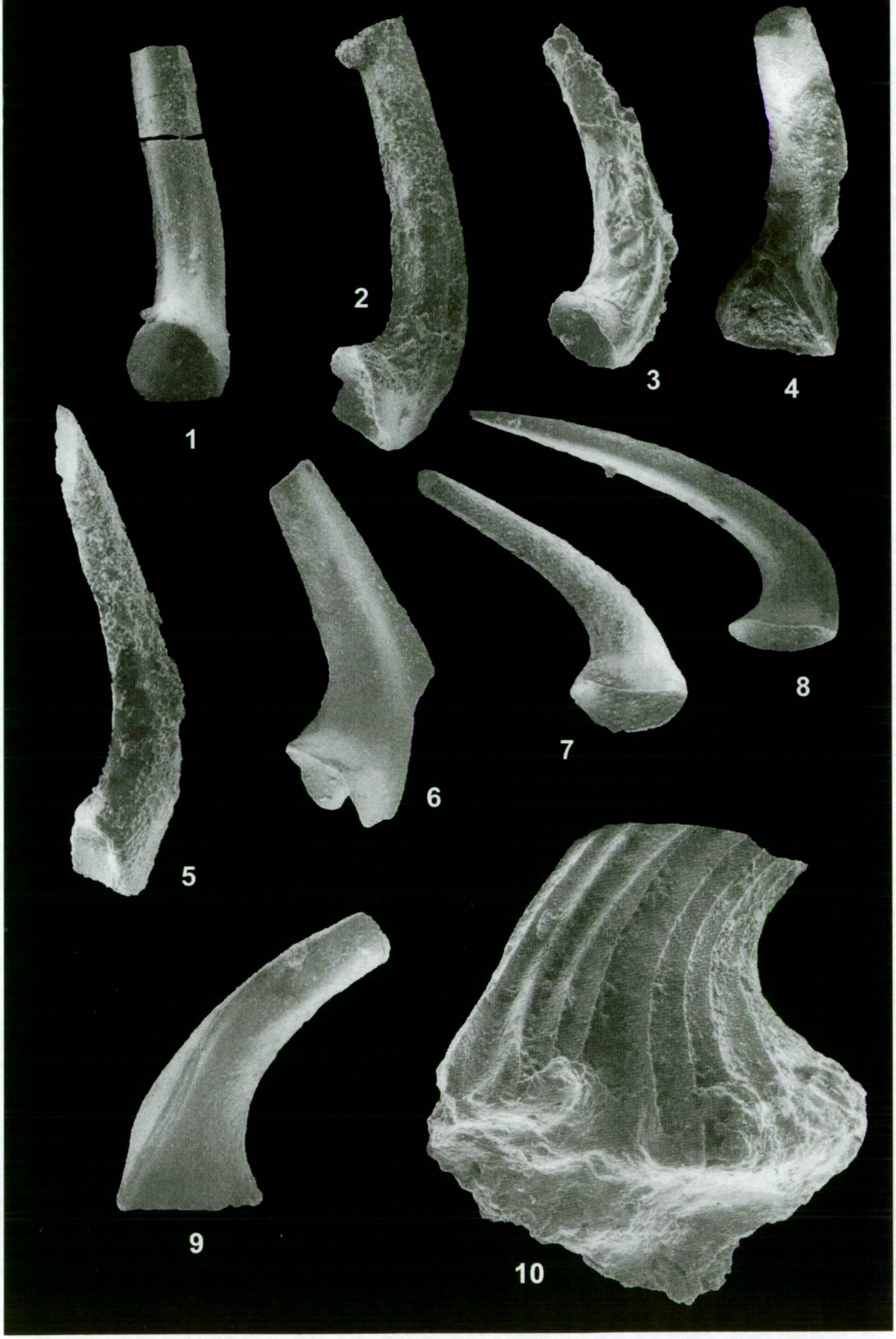

Plate 6.16.

Figs. 1–11. *Scolopodus rex* LINDSTRÖM.

Fig.1. Lateral view of a b element. Sample KARM 6, X150. TUGD128513

Fig. 2. Lateral view of an *f* element. Sample KARM 7, X115. TUGD128514

Fig. 3. Lateral view of the upper cusp of an *a* element.
Sample KARM 7, X105. TUGD128515

Fig. 4. Lateral view of the base of an *e* element.
Sample KARM 7, X135. TUGD128516

Fig. 5. Lateral view of an *a* element. Sample KARM 6, X165. TUGD128517

Fig. 6. Lateral view of the upper cusp of an *a* element.
Sample KARM 4, X105. TUGD128518

Fig. 7. Lateral view of an *a* ?element. Sample KARM 5, X100. TUGD128519

Fig. 8. Lateral view of a *b* element. Sample KARM 4,X160. TUGD128520

Fig. 9. Lateral view of a *b* element. Sample KARM 4, X120. TUGD128521

Fig. 10. Lateral view of an *f* element. The basal region is damaged.
Sample KARM 6? X125. TUGD128522

Fig. 11. Lateral view of an *a* element. Sample KARM 4, X145. TUGD128523

Fig. 12. *Scolopodus krummi* LEHNERT. Lateral view of an *a* element.
Sample KARM 8, X90. TUGD128524

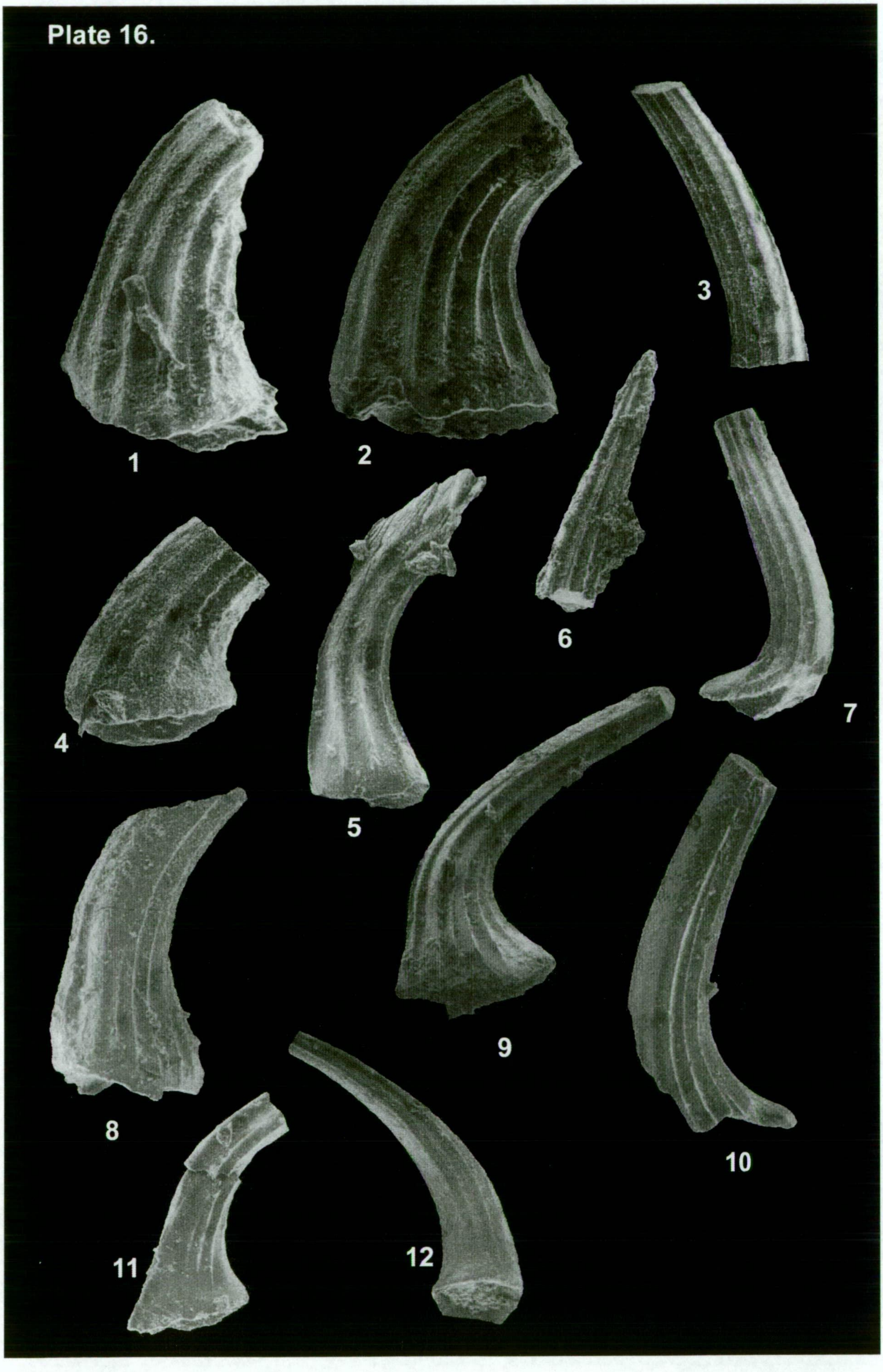
Plate 16.
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Plate 6.17.

Figs. 1–2.. *Scolopodus rex* LINDSTRÖM.

Fig. 1. Lateral view of the upper cusp of an *a* element.
Sample KARM 4, X200. TUGD128525

Fig. 2. Lateral view of an *e* ? element. Sample KARM 5, X75. TUGD128526

Fig. 3. *Scolopodus* sp. LINDSTRÖM. Lateral view of a damaged cusp of an .
e element Sample KARM 10, X80. TUGD128527

Figs. 4–9. *Scolopodus krummi* LEHNERT (1995).

Fig. 4. Lateral view of an *f* element. Sample KARM 6, X95. TUGD128528

Fig. 5. Lateral view of a *c* element. Sample KARM 4, X75. TUGD128529

Fig. 6. Lateral view of a *c* element. Sample KARM 8, X125. TUGD128530

Fig. 7. Lateral view of a *b* element Sample KARM 7, X100. TUGD128531

Fig. 8. Lateral view of a *b* element. Sample KARM 8, X100. TUGD128532

Fig. 9. Lateral view of a *c* element. Section KARM 4, X155. TUGD128533

Fig. 10. *Semiacontiodus cornuformis* SERGEEVA.
Lateral view of a damaged Sd element. Sample KARM 6, X150. TUGD128534

Fig. 11. Cusp of a damaged *Scolopodus* sp. aff. *S. filosus* Drepanodiform (Sd) element.
Sample KARM 2, X550. TUGD128535

Fig. 12. *Scolopodus krummi* LEHNERT (1995). Lateral view of an *a* element.
Sample KARM 2, X 150. TUGD128536

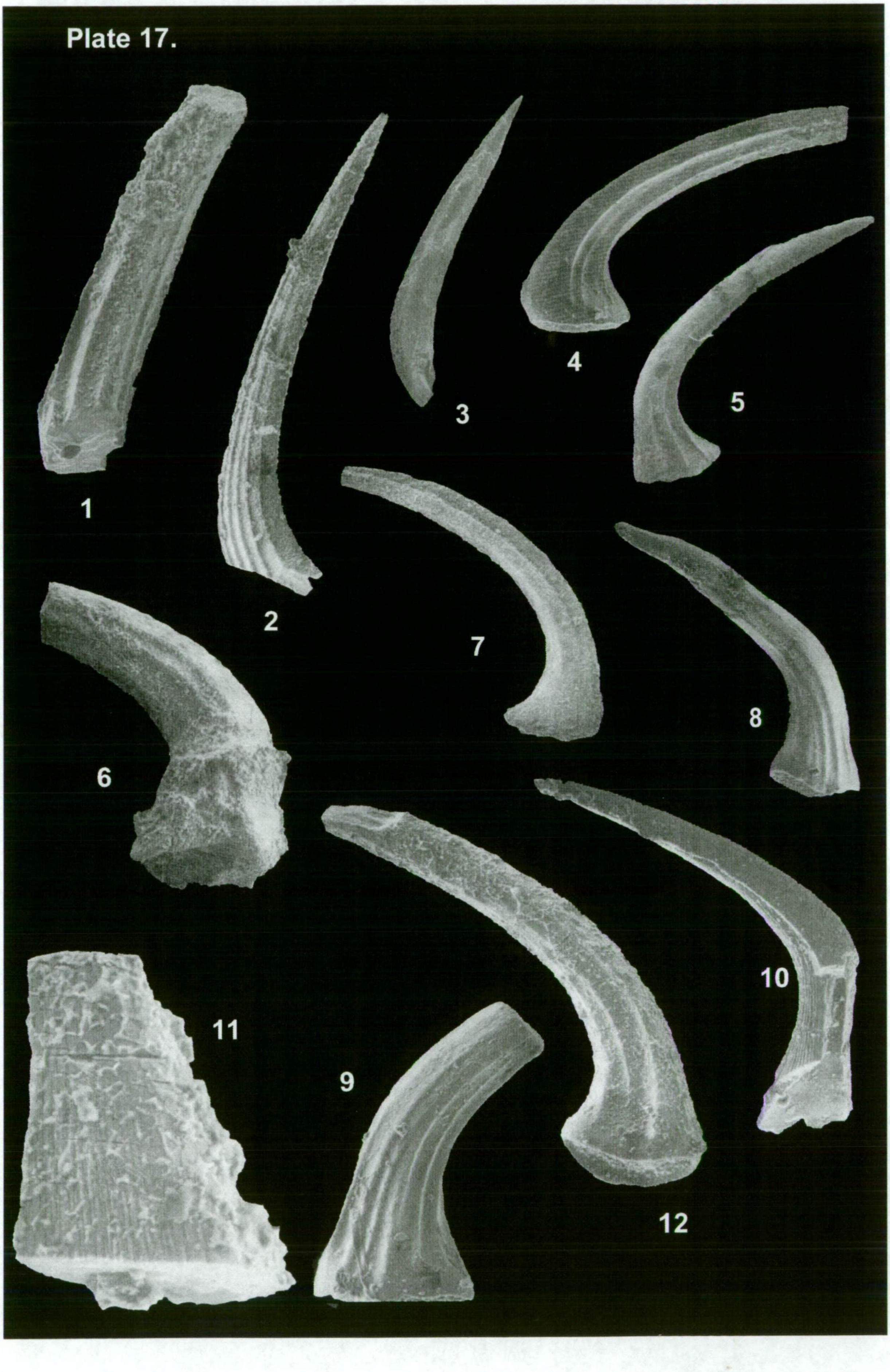
Plate 17.
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Plate 6.18.

Figs. 1–6. *Triangulodus* cf. *T. brevibasis* SERGEEVA.

Fig.1. Lateral view of an Sc element. Sample KARM 7, X115.	TUGD128537
Fig. 2. Lateral view of an Sa element. Sample KARM 4, X125.	TUGD128538
Fig. 3. SERGEEVA. Lateral view of an Sc element. Sample KARM 6, X110.	TUGD128539
Fig. 4. Lateral view of an Sc element. Sample KARM 8, X110.	TUGD128540
Fig. 5. Lateral view of an M element. Sample taken on Settlement Road within the Cashions Creek Formation. Section SETT. 1. X 90.	TUGD128541
Fig. 6. Lateral view of an Sc element. Sample KARM 4, X110.	TUGD128542

Fig. 7. *Stolodus* sp. aff. *Stolodus stola* LINDSTRÖM.

Lateral view of element. Sample KARM 5, X85. TUGD128543

Fig. 8. *Triangulodus larapintinensis* (CRESPIN), *sensu* COOPER (1986).

Fig. 8. Lateral view of a damaged element. Sample KARM 7, X215. TUGD128544

Plate 18.

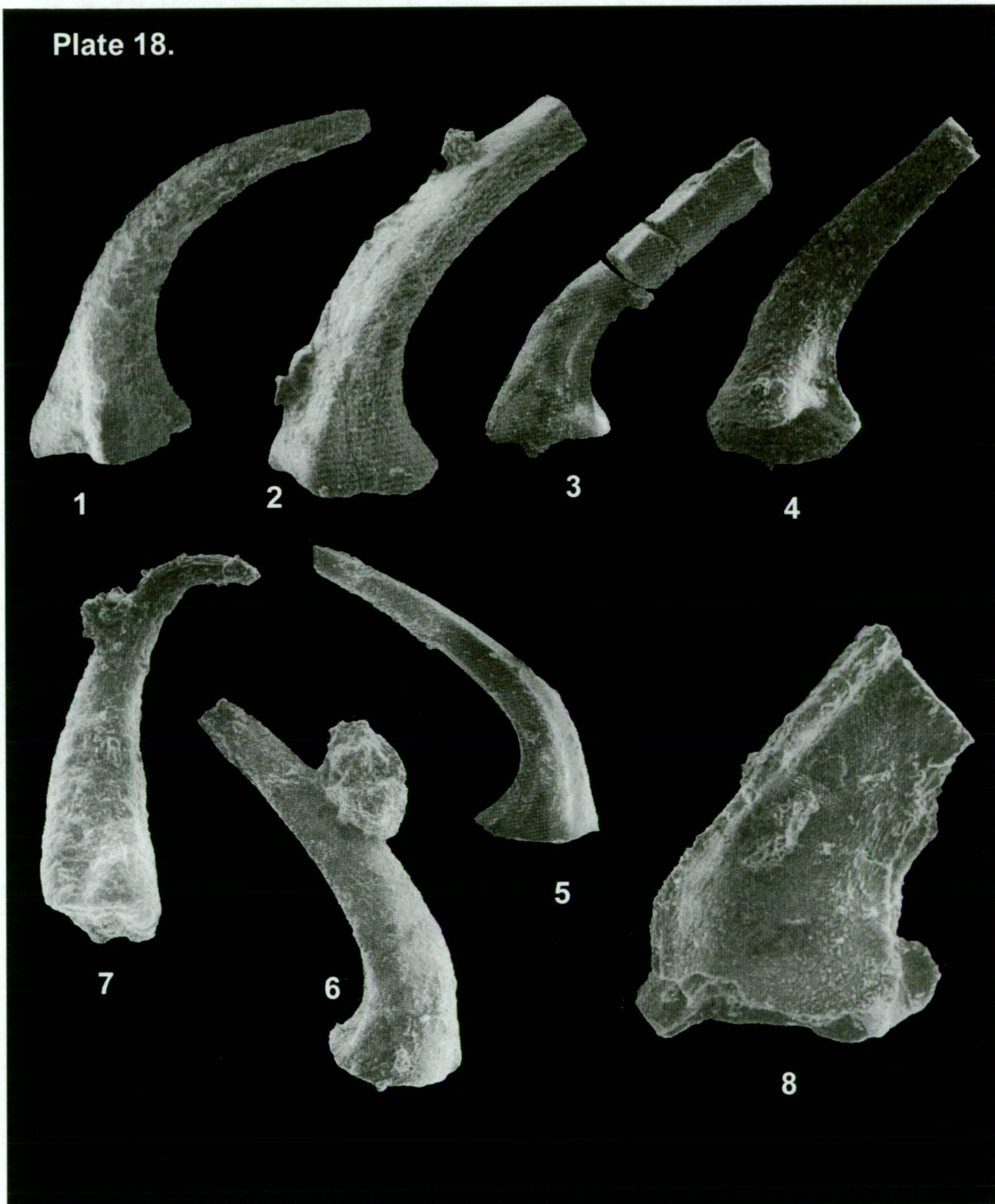


Plate 6.19.

Figs. 1-6 *Variabiloconus variabilis* LINDSTRÖM (1955)

Fig. 1. Lateral view of an Sd element. Sample KARM 4, X125.	TUGD128545
Fig. 2. Lateral view of an Sd element. Sample KARM 2, X185	TUGD128546
Fig. 4. Lateral view of an Sd element. Sample KARM 1, X150.	TUGD128547
Fig. 5. Lateral view of an Sd element. Sample KARM 4, X150.	TUGD128548
Fig. 6. Lateral view of an Sd element. Sample KARM 10, X 100.	TUGD128549

Figs. 7-9. Unassigned species.

Fig. 7 Lateral view of a gastropod shell. Sample KARM 2, X160. TUGD128550

Fig. 8. Lateral view of the pygidium of the trilobite ?*Parapileka acucodata* STAIT (1976, unpub.). Sample KARM 2, X125. TUGD128551

Fig. 9. *Hystricurus* cf. *timsheaensis* STAIT (1976, unpub.). Pygydium of a trilobite. Sample KARM 8, X125. TUGD128552

Fig. 10. Unassigned conodont element. Section KARM 2, X155. Ramiform element. The encrustation on the damage to the element makes it impossible to make an accurate diagnosis. TUGD128553

Plate 19.

Plate 6.20.

Fig. 1. *Protopanderodus rectus* LINDSTRÖM. Lateral view of an Sb element.
Sample KARM 10, X180. TUGD128554

Fig. 2. *Protopanderodus rectus* LINDSTRÖM. Lateral view of an Sb element
. Sample KARM 8, X120. TUGD128555

Fig. 3. *Drepanodus* sp. cf. *D. concavus* BRANSON & MEHL. Lateral view
of an S element. Sample KARM 8, X115. TUGD128556

Fig. 4. *Drepanoistodus basiovalis* SERGEEVA.
Basal oblique view of an M element. Sample KARM 4, X65. TUGD128557

Fig. 5. *Protopanderodus varicostatus* SWEET & BERGSTRÖM. Posterolateral
view of the basal region of an Sa element. Sample KARM 4, X60. TUGD128558

Figs. 6, 7. *Protopanderodus* sp.
Fig .6. Lateral view of the basal region of an *a-b* element.
Sample KARM 9, X180. TUGD128559
Fig. 7. Lateral view of an *e* element. Sample KARM 9, X110. TUGD128560

Fig. 8. *Rossodus manitousensis* REPETSKI & ETHINGTON. Lateral view
of a *b* element. Sample KARM 8, X90. TUGD128561

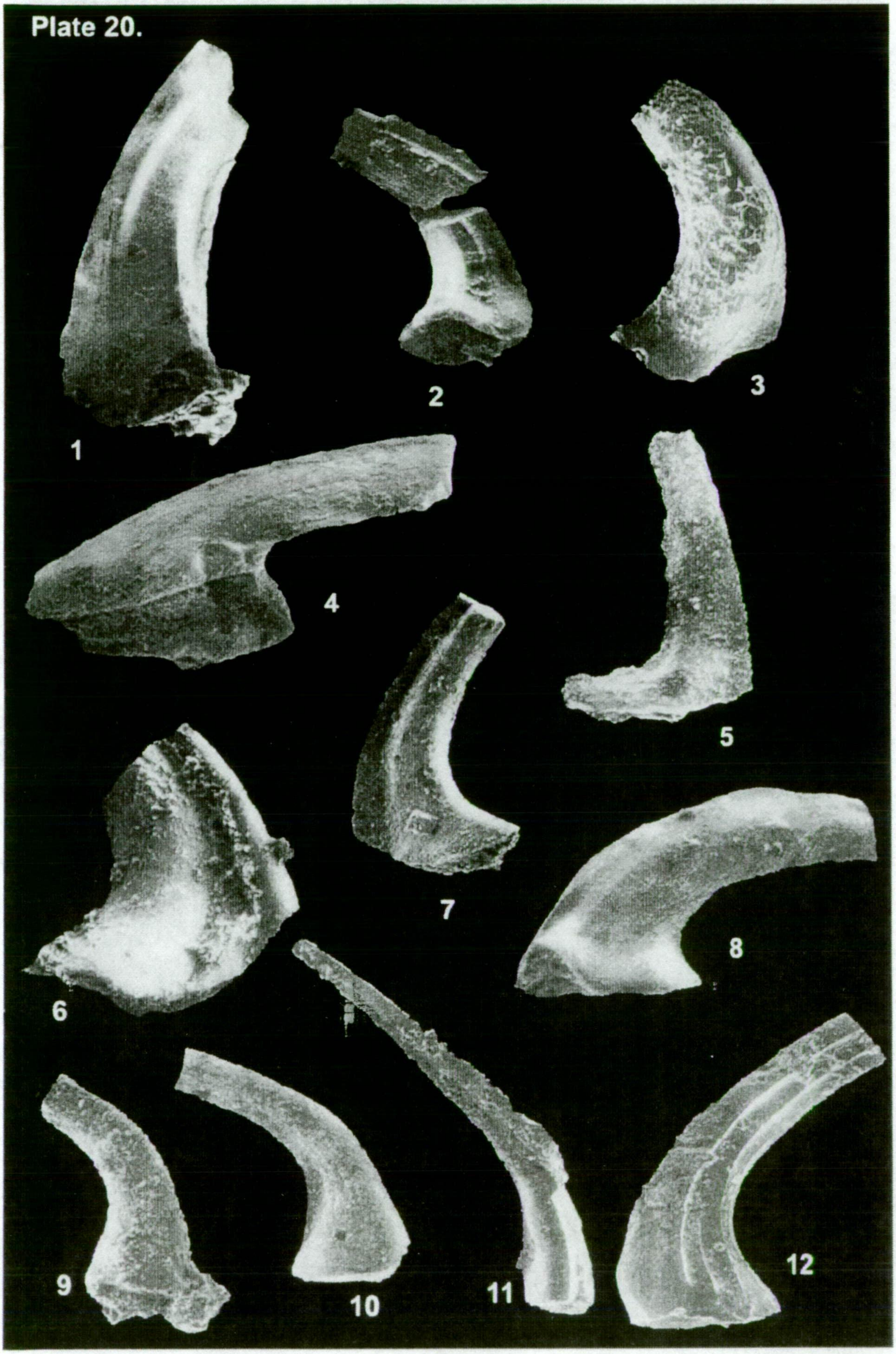
Fig. 9. *Scalpellodus* sp. cf. *S. tersus*. Lateral view of the basal region of an Sa
element. Sample KARM 4, X115. TUGD128562

Fig. 10. *Cornuodus longibasis* LINDSTRÖM. Lateral view of element.
Sample KARM 10, X100. TUGD128563

Fig. 11. *Protopanderodus elongatus* ? SERPAGLI (1974). Lateral view of a
damaged ?*c* element. Sample KARM 7, X75. TUGD128564

Fig. 12. *Protopanderodus gradatus* SERPAGLI. Lateral view of a *c* element.
Sample KARM 4, X 100. TUGD128565

Plate 20.



Chapter 7.

The Middle–Upper Ordovician distribution of the conodont genus *Phragmodus* BRANSON & MEHL from the Gordon Group, Tasmania.

Introduction.

Phragmodus is widely distributed in Laurentia Siberia and Greater Gondwana from the Middle to Upper Ordovician.

Phragmodus is widely distributed in shallow, warm, open marine environments and is rare in extreme peritidal carbonates (BERGSTRÖM & SWEET 1966, WINDER 1966, SCHOPF 1966, GLOBENSKY & JAUFFRED 1971, CRESSMAN 1973, BARNES & FÅHRÆUS 1975, MOSKALENKO 1976, WEBBY 1992, RIGBY & WEBBY 1988, NOWLAN & NEUMAN 1995 and TROTTER & WEBBY 1994).

Three species including *Phragmodus undatus* BRANSON & MEHL, *Phragmodus flexuosus* MOSKALENKO and a new species referred to as *Phragmodus tasmaniensis* have been recorded from Middle to Late Ordovician limestones of the Gordon Group in Tasmania (BURRETT (1978, unpub.).

Correlation in the U.S.A. and Europe.

The cosmopolitan nature of *Phragmodus* permits a correlation within the North American Midcontinent Province (BRADSHAW 1969, SWEET & BERGSTRÖM 1971), Scandinavia, the United Kingdom (ARMSTRONG 1996), Siberia (MOSKALENKO 1973), the Baltic regions (BERGSTRÖM 1973, p. 268), Canada (SWEET, et al., 1971, p.177, 180, MCCRACKEN & BARNES 1981 and BARNES 1988).

Lithostratigraphy of the Gordon Group, Tasmania.

The Ordovician Limestones in Tasmania have been fully discussed by BANKS (1962), BANKS & BAILLIE (1974), BANKS & BURRETT (1980), BURRETT et al., (1983), BURRETT, et al., (1984), WEBBY et al., (1981), CANTRILL & BURRETT (2002, in press) and in Chapter 7 of this study. The Gordon Group ranges in age from the Lower Ordovician through to the Upper Ordovician. The bulk of the group is composed of relatively pure, shallow water limestones deposited in a relatively stable environment.

Fig. 7.1. Location sites of *Phragmodus undatus* BRANSON & MEHL, *Phragmodus flexuosus* MOSKALENKO and *Phragmodus tasmaniensis* n. sp. in Tasmania.
After BURRETT (1978, unpub.) and BURRETT et al., (1984).

KEY.

1. Andrew River.
2. Chudleigh.
3. Claude Creek.
4. Darwin Crater.
5. Eugenana–Melrose–Paloona.
6. Everlasting Hills.
7. Florentine Valley.
8. Gunn's Plains.
9. Hastings Caves.
10. Judd's Cavern.
11. Lower Gordon River.
12. Liena.
13. Lorinna.
14. Lower Gordon River.
15. Mole Creek.
16. Moina.
17. Olga River.
18. Zeehan.
19. Ida Bay.
20. Surprise Bay.
21. Precipitous Bluff
22. Bub's Hill

TFZ Tamar Fault Zone.

Palaeoenvironments of the Gordon Group, Tasmania.

BANKS & BAILLIE (1989), In: RAO (1997) noted that Tasmania was situated within the subtropics (10°N) during the Ordovician. Newer palaeomagnetic data cited in Chapter 4, fig. 4.1. of this thesis indicates that Tasmania was closer to the Equator during the Middle to Upper Ordovician (CANTRILL & BURRETT 2002, in press).

The Gordon Group of limestones have a low faunal diversity. This may be due to an unstable intertidal environment. A high rate of evaporation causes a higher salinity in shallower intertidal regions.

Correlation with other successions in Tasmania, Australia.

BURRETT (1978, unpub.) recorded *Phragmodus* n. sp. in a conodont fauna which had an equivalent age of a Blackriveran conodont fauna (Fauna 7) of North America. He suggested that the Tasmanian biostratigraphic scheme of BANKS & BURRETT (1980) may be used to correlate the Gordon Group with North America Midcontinent Faunal Assemblages.

In the Gordon Limestone sequences of Tasmania *Phragmodus undatus* BRANSON & MEHL is found in association with a conodont fauna which includes *Bryantonia ?abrupta, Oistodus robustus, Oistodus oregonia* and *Scolopodus falcata.*

In southern Tasmania *Phragmodus tasmaniensis* n. sp. and *Phragmodus undatus* BRANSON & MEHL were also reported from the peritidal deposits from Ida Bay. The Ida Bay fauna ranged in age from Middle Darriwilian to Early Ashgill. BURRETT et al., (1984) suggested that the New River Beds had a similar age to the Cashions Limestone from the Florentine Valley (Upper Whiterockian=Darriwilian).

Amadeus Basin, Central Australia.

ZHANG et al., (2000) recorded a late Middle Ordovician, (late Gisbornian) North American Midcontinent conodont fauna within the lower part of the Stokes Siltstone. *Phragmodus* n. sp. and *Oulodus oregonia* formed some 60% of the total fauna.

Wahringa Limestone Member, N.S.W.

An age of upper Middle Ordovician through to basal Late Ordovician (Darriwilian Da2 to Gisbornian Gi1) for the Wahringa Limestone Member conodont fauna. As the conodont assemblage includes *Phragmodus flexuosus* PERCIVAL et al., (1999) gave a restricted age of Da3 to Gi1 for that part of the fauna.

Table 7.1. Summary of the depositional environments in Tasmania

	Location	Reference	Environment
1.	Florentine Valley	Fig. 7.1 (7)	Tranquil, sublittoral environment in lower part, intertidal in upper part.
2.	Mole Creek	Fig. 7.1. (5)	Deep subtidal environment Depth 5 to 10m. Subtidal regime.
3.	Surprise Bay.	Fig. 7.1 (20).	Deeper water, environment. Dark grey thinly bedded micrites, graptolitic shales.
4.	Ida Bay	Fig. 7.1 (19).	High intertidal to high subtidal. Cold water limestones. Shallow platform deposits including biosparites & biocalcarenites.
5.	Precipitous Bluff Point Cecil	Fig. 7.1 (21).	Shallow shelf edge to and deepening marine sediments. Mainly peritidal sequences.
6.	Smelters Quarry (Zeehan)	Fig. 7.1 (18)	Intertidal. Gastropods, calcareous and carbonaceous Siltstones and dolomites.
7.	Bub's Hill	Fig. 7.1 (22)	Bioturbatic, dolomitic sediments.

From WELDON (1974), BANKS & BURRETT (1980), BURRETT et al., (1982), BURRETT et al., (1984) and CALVER (1990).

Reedy Creek Limestone, Molong, N.S.W.

PERCIVAL et al., (1999) also recorded a possible specimen of *Phragmodus undatus* from the Reedy Creek Limestone within the Oakdale Formation north of Molong. Brachiopod and conodont faunas suggest an age range of Late Middle to basal Early Ordovician (Darriwilian to Gisbornian from Da4 to Gi2) in Australia.

Sourges Shale. Cumnock, N.S.W.

Based upon the presence of *Phragmodus undatus* in these shales PERCIVAL et al., (1999) gave an age of Middle Caradoc (Eastonian Ea2 to Ea3) for this fauna.

Distribution of species of the genus *Phragmodus* in Tasmania.

Tables 7.4, (1–3), and 7.5 shows the frequency and distribution of the different types of elements for each species found in Tasmania (BURRETT 1978 unpub., BURRETT & BANKS 1980 and BURRETT et al., (1984).

Table 7.2. Location of sites of the more common species of *Phragmodus*, viz. *Phragmodus* n. sp. *Phragmodus undatus*, *Phragmodus flexuosus* in Tasmania.

Gordon Group Limestones	*Phragmodus* Species. *Phragmodus undatus*	*Phragmodus flexuosus*	*Phragmodus tasmaniensis* n.sp.
Northern Tasmania.			
1. Andrews River/Darwin Crater	+		
2. Bub's Hill		+	
3. Claude Creek	+		
4. Eugenana-Melrose-Paloona	+		
5. Lower Barrington			+
6. Everlasting Hills.			+
Florentine Valley: (7–9)			
7. Lower L/stone Member	+	+	+
8. Lords Siltstone Member	+		
9. Upper L/stone Member	+		
10. Gunns Plains	+		
11. Judd's Cavern	+		
12. Liena	+		
13. Loongana	+		
14. Lune River	+		
15. Moina	+		
16. Chudleigh Formation:	+		
17. Mole Creek Formation	+	+	+
18. Standard Hill Member	+		
19. Sassafras Member	+		
20. Dog's Head	+		
21. Overflow Creek	+		
22. Den Member	+		
23. Olga River–Gordon River	+		
Southern Tasmania.			
24. Picton River	+		
25. Zeehan			+
26. Ida Bay.	+	+	
27.Precipitous Bluff			+

Table 7.3. Location of sites of the more common species of *Phragmodus*, viz. *Phragmodus* n. sp. *Phragmodus undatus*, *Phragmodus flexuosus* in Tasmania.

Gordon Group Limestones	*Phragmodus* Species.		
	Phragmodus undatus	*Phragmodus flexuosus*	*Phragmodus tasmaniensis* n.sp.
Northern Tasmania.			
1. Andrews River/Darwin Crater	+		
2. Bub's Hill	+		
3. Claude Creek	+		
4. Eugenana-Melrose-Paloona	+		
5. Lower Barrington		+	
6. Everlasting Hills.			+
Florentine Valley: (7–9)			
7. Lower L/stone Member	+	+	+
8. Lords Siltstone Member	+		
9. Upper L/stone Member	+		
10. Gunns Plains	+		
11. Judd's Cavern	+		
12. Liena	+		
13. Loongana	+		
14. Lune River	+		
15. Moina	+		
16. Chudleigh Formation:	+		
17. Mole Creek Formation	+	+	+
18. Standard Hill Member	+		
19. Sassafras Member	+		
20. Dog's Head	+		
21. Overflow Creek	+		
22. Den Member	+		
23. Olga River–Gordon River	+		
Southern Tasmania.			
24. Picton River	+		
25. Zeehan			+
26. Ida Bay.	+	+	
27. Precipitous Bluff			+

Table 7.4. Sites where *Phragmodus* sp. *Phragmodus undatus* BRANSON & MEHL *Phragmodus flexuosus* MOSKALENKO occur in Australia, North America, Europe and China.

Country	Conodont species		
	Phragmodus sp.	*Phragmodus undatus* BRANSON & MEHL	*Phragmodus flexuosus* MOSKALENKO
Canada.			
Anticosti Islands	+		
Ellis Bay Fm.		+	
Ships Point Fm.	+		+
Coburg Fm.		+	
Bad Cache Rapids.		+	
Whitehead Fm.		+	
Cap Blanc (Queb.).		+	
Broken Skull Fm.	+		
Haywire Fm.		+	
Whittaker Fm.		+	+
Duo Lake Fm.		+	
Sapper Fm.		+	
Manitoulin Is.		+	
L. Collingwood Beds		+	
(Whitby Fm.)		+	
Georgian Bay Fm.		+	
Mid. Verulam Fm.		+	
Grog Brook Fm.		+	
Winnepeg Fm.	+		
Argentina.			
Las Arguaditas Fm.			+?
Southeast Asia			
South China.		+	
Europe.			
Siberia		+	+
Volginski Beds			+
Kulumba Sect.			

Country	Conodont species		
	Phragmodus sp.	*Phragmodus undatus* BRANSON & MEHL	*Phragmodus flexuosus* MOSKALENKO
Wales	+?		
Scotland	+	+	
Poland.	+		
Central Sweden.	+		
Norway		+	
Finland	+		
U.S.A. Cottingham Ck. (Alab.)			+
Antelope Valley			+
East.Oklahoma.			+?
Covington Group.			
Eden Fm.		+	
Fairview Fm.		+	
McMillan Fm.		+	
Bellevue Fm.		+	
Pratt Ferry, Alab.			+
Lehman Fm.			+
Kope Fm.		+	
Lexington Fm.		+	
Clay Ferry Fm.		+	
Plattville Fm.		+	
Joachim Dolomite		+	
Upper Bromide Fm.		+	+
Burgen–Tyner Fm.	+		
Fite & Viola Group.	+	+	
Lehman Fm. (Nev.).			+
Glenwood Fm.	+		
Decorah Shales	+		
Keisley L/st.	+		
Lenoir Fm.	+		
Fort Peña (Tex.).	+		
Womble Shale (Ark)	+		
St Peters S/st. (Ind.).	+		
Ibex Area, Utah		+	

Country	Conodont species		
	Phragmodus sp.	*Phragmodus undatus* BRANSON & MEHL	*Phragmodus flexuosus* MOSKALENKO
Australia.			
Fork Lagoons Qld.).		+	
Wahringa L/St.(NSW)			+
Sourges Fm. (NSW)	+	+	
Sofala.(NSW)	+		
Upper Reedy Ck. Fm.(NSW)		+?	
Trelawney Beds.(NSW)		+	
Mallongulli Fm.(NSW)		+	
*Tasmania		+	+
* Gordon Limestone	+	+	+

Table 7.6 The distribution of the types elements of *Phragmodus undatus, Phragmodus flexuosus and Phragmodus tasmaniensis.* n. sp. from the different locations within the Gordon Group, Tasmania.

LOCATION	Element types	*Phragmodus tasmaniensis n. sp.*	*Phragmodus undatus* BRANSON & MEHL	*Phragmodus flexuosus* MOSKALENKO	TOTAL
Mole Creek.					
	M				
	Sc		2+1?		2+1
	Sb		2	1	3
	Sa	4+1?	2+1?	4+1?	10+3?
	Pa		1?+1?		1?+1?
	Pb			1?	1?
Bub's Hill.					
	M			1	1
	Sc		2	1	3
	Sb			1	1
	Sa				
	Pa				
	Pb				
Ida Bay					
	M		1	1	2
	Sd		1?		1?
	Sc	1	2		3
	Sb	1		1?	1+1?
	Sa			2	2
	Pa				
	Pb			1	
Culver					
	M				
	Sc			2	2
	Sb	1			1
	Sa			1?	1?
	Pa				
	Pb				
The Den					
	M				
	Sc		4		4
	Sb		3		3
	Sa	1			1
	Pa		1		1
	Pb				
Florentine Valley					
	M			1	1
	Sc				
	Sb				
	Sa	1		1	2
	Pa		1		1
	Pb				
Zeehan.					
	M				
	Sc				
	Sb				
	Sa	1?			1?
	Pa			1?	1?
	Pb				
TOTAL		11	25	21	= 57

Fig. 7.3. Part 1.

Sketched diagrams of the elements of three different species of the Genus *Phragmodus* BRANSON & MEHL, *Phragmodus undatus* BRANSON & MEHL, *Phragmodus flexuosus* MOSKALENKO and *Phragmodus tasmaniensis* n. sp. Other sources have been used to complete an Assemblage Plan. The architecture of the different species of *Phragmodus* is based upon the work of SWEET & SCHÖNLAUB (1975), ZIEGLER (1981) and NICOLL (1995).

	M	**Sc**	**Sb**	**Sa**	**Pa**	**Pb**	
ANTERIOR							POSTERIOR
	e	**a**	**b**	**d**	**f**	**g**	

Figs. 1–6. *Phragmodus* sp. BRANSON & MEHL.

All elements are sketched from ZIEGLER (1981, Ed.), *Catalogue of Conodonts* **IV**, p. 245.

Figs. 7–12. *Phragmodus undatus* BRANSON & MEHL. The elements in figs. 7, 8, 11, are sketched from Plate 2, SWEET, et al. (1971).

The Sa element is sketched from BURRETT (1978 unpub.).

The Sb element is sketched from AMSDEN & SWEET, (1983).

7. M element: Pl. 2, fig. 7, (Reverse image).
8. Sc element: Pl. 2, fig. 10.
9. Sb element: Pl. 3, fig. 12, AMSDEN & SWEET (1983).
10. Sa element: From BURRETT (1978 unpub). Fig. 55D.
11. Pb element: Pl. 2, fig. 9.
12. Pa element: Pl. 2, fig. 8.

Figs. 13–18. *Phragmodus undatus* BRANSON & MEHL

13. M element: From BARNES (1988, Pl. 1, fig. 22).
14. Sc element: From BARNES (1988, Pl. 1, fig. 23).
15. S (Sb) element: From PHILIP, (1966, fig. 5).
16. Sa element: From BARNES (1988, Pl. 1, fig. 21).
17. Pb element: From BERGSTRÖM (1990).
18. Pa element: From BERGSTRÖM (1990, Pl. 4, fig. 9).

Figs. 19–24. *Phragmodus undatus* BRANSON & MEHL

All elements sketched from BURRETT (1978 unpub.).

19. M element: Fig. 56A.
20. Sc element: Fig. 56 B.
21. Sb element: Fig. 55 F.
22. Sa element: Fig. 55D.
23. Pb element: Fig. 56F
24: No specimen available.

Fig. 7.3. Part 2.

Figs. 25–30. *Phragmodus flexuosis* MOSKALENKO.

Sketches of elements forming the Apparatus of each species are taken from ZIEGLER (1981, Ed.). *Catalogue of Conodonts*, **IV**, p. 259.

25. M element: Pl. 2, fig. 6.
26. Sc element: Pl. 2, fig: 2.
27. Sb element: Pl. 2, fig. 1.
28. Sa element: Pl. 2, fig. 5.
29. Pb element: Pl. 2, fig. 3.
30. Pa element: Pl. 2, fig. 4.

Figs. 31–36. *Phragmodus flexuosis* MOSKALENKO.

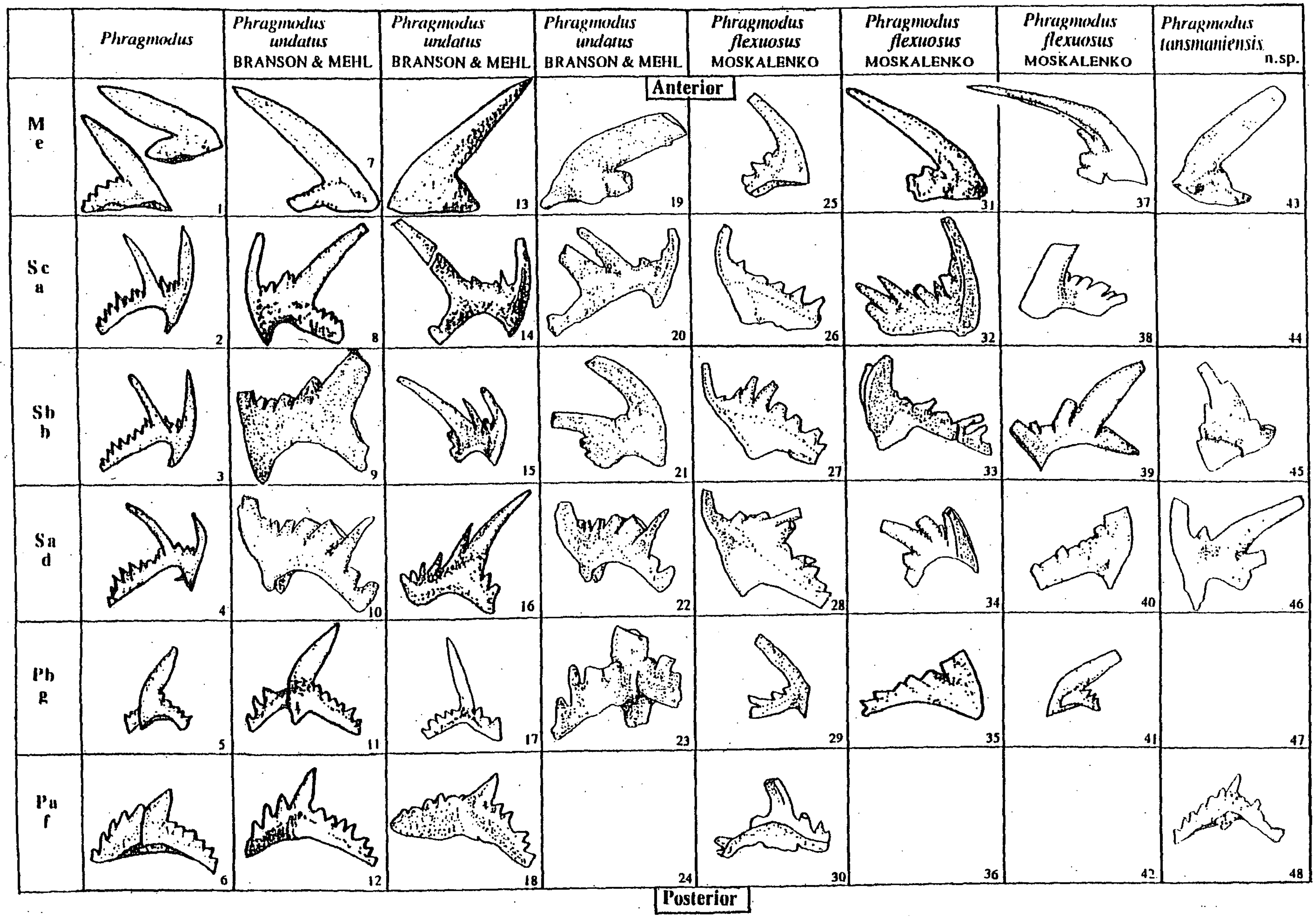
31. M element: From SHAW et al. (1989), Pl. 1, fig. 2.
32. Sa element: From PERCIVAL et al. (1999), Fig. 8, 8.15.
33. Sb element: From PERCIVAL et al. (1999), Fig. 8, 8.14.
34. Sc element: From BURRETT (1978, unpub.), Fig. 51F.
35. Pb element: From SHAW et al. (1989), Pl. 1, fig. 3.
36. No specimen available.

Figs. 37–42. *Phragmodus flexuosus* MOSCALENKO. From Tasmania.

37. M element: From BURRETT (1978, unpub). Fig. 50G.
38. Sc element: From BURRETT (1978, unpub). Fig. 50I.
39. Sb element: From BURRETT (1978, unpub). Fig. 51D.
40. Sa element: From BURRETT (1978, unpub). Fig. 50C.
41. Pb element: From BURRETT (1978, unpub). Fig. 50L.
42. No specimen available.

Figs. 43–48. *Phragmodus tansmaniensis* n. sp. from Tasmania.

43. M element: From BURRETT (1978, unpub). Fig. 54 C
44. No specimen available.
45. Sb element: From BURRETT (1978, unpub). Fig. 53 A
46. Sa element: From BURRETT (1978, unpub). Fig. 54 A
47. No specimen available.
48. Pa element: From BURRETT (1978, unpub). Fig. 53 C



Phragmodus
Phragmodus undatus BRANSON & MEHL
Phragmodus undatus BRANSON & MEHL
Phragmodus undatus BRANSON & MEHL
Phragmodus flexuosus MOSKALENKO
Phragmodus flexuosus MOSKALENKO
Phragmodus flexuosus MOSKALENKO
Phragmodus tansmaniensis n.sp.
Anterior
M e
Sc a
Sb b
Sa d
Pb g
Pa f
Posterior
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48

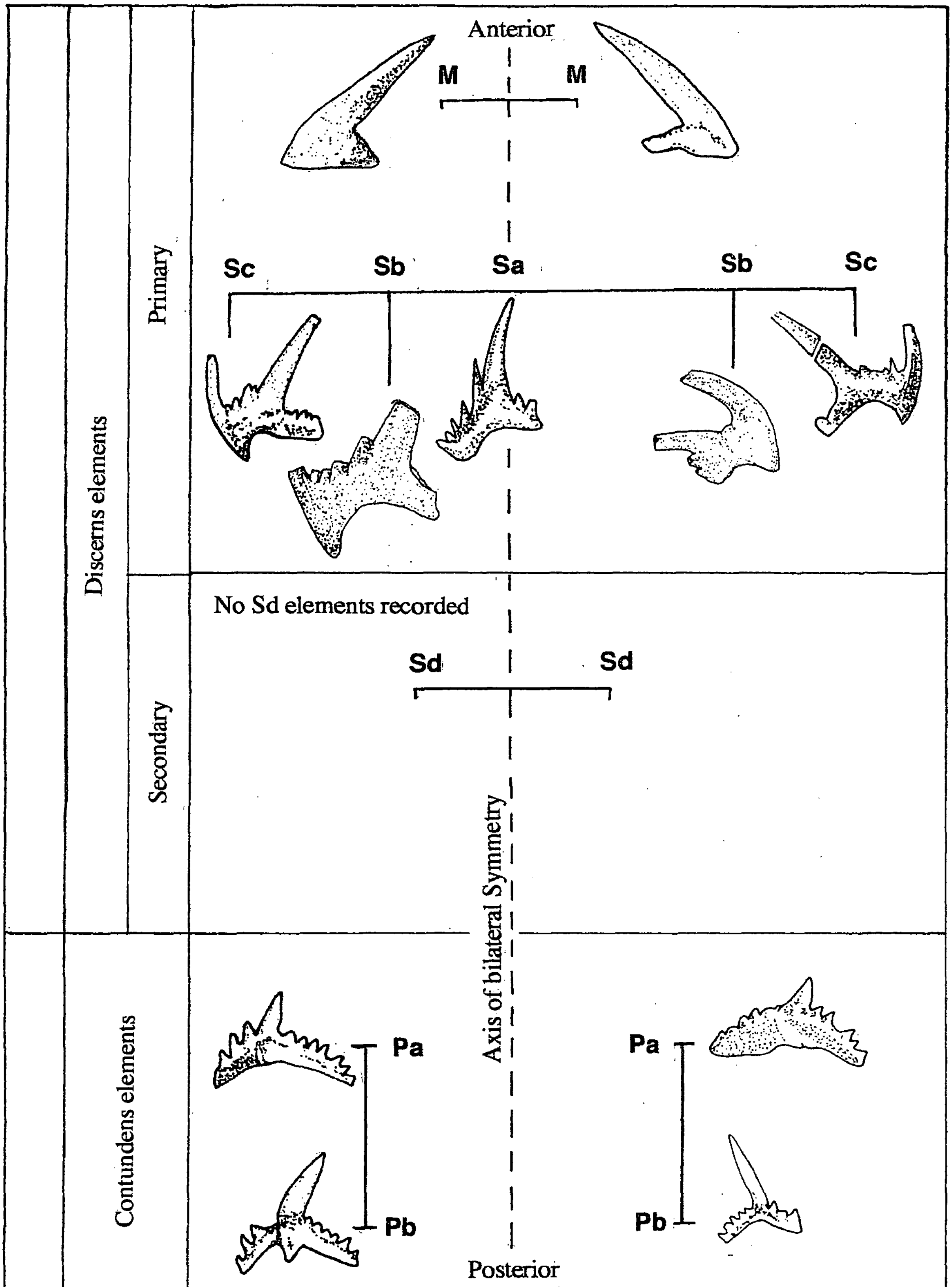


Fig. 7.4.

A proposed model of the architecture of *Phragmodus undatus* BRANSON & MEHL using the morphology and apparatus model of NICOLL (1995).

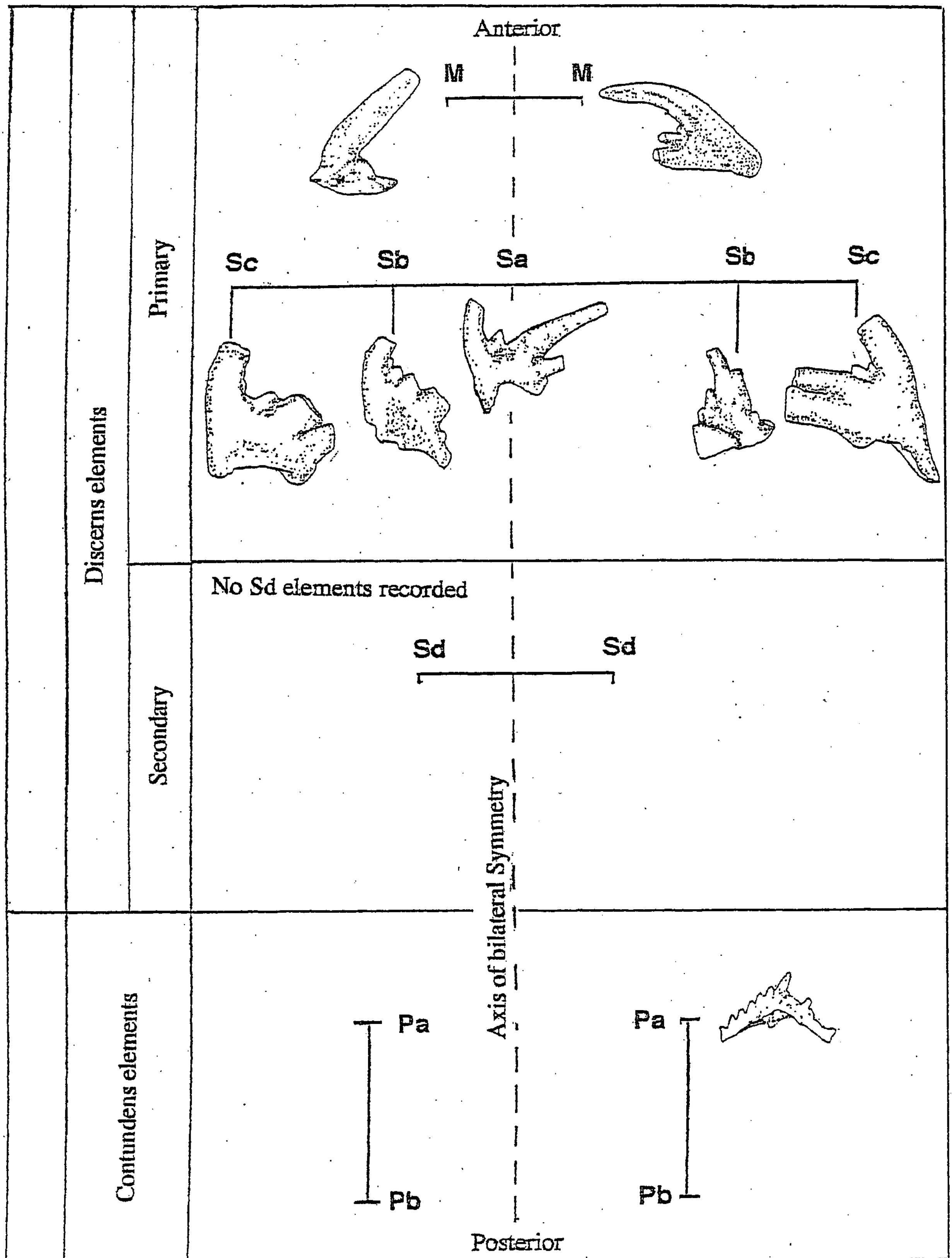


Fig. 7.5. A proposed model of the architecture of *Phragmodus tasmaniensis* n. sp. using the morphology and apparatus model of NICOLL (1995).

After NICOLL (1995, p. 248.)

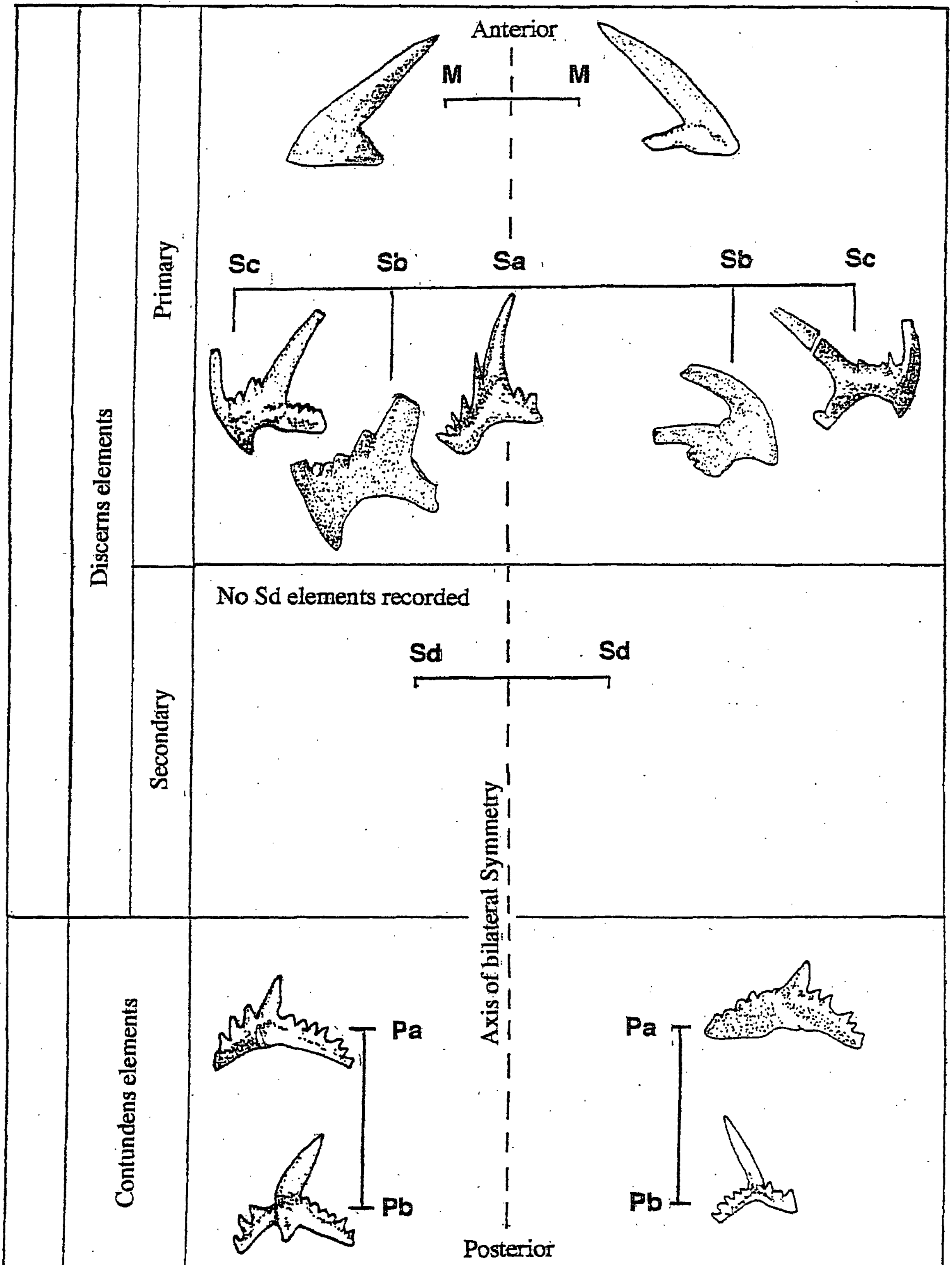


Fig. 7.6.

A proposed model of the architecture of *Phragmodus undatus* BRANSON & MEHL using the morphology and apparatus model of NICOLL (1995).

After NICOLL (1995, p. 248).

Systematic Palaeontology.

All elements of the species of *Phragmodus* discussed in this paper were obtained from the Gordon Group (Ordovician) limestones in Tasmania. They are a part of a collection that is stored with the Curator, School of Earth Sciences, University of Tasmania, Hobart, Tasmania.

Regional references only are given as exact GPS References are unavailable.

The Assemblage Plan for the three *Phragmodus* species (Figs. 7.2–7.4) discussed in this chapter are based upon an Assemblage Plan proposed by SWEET & SCHÖNLAUB (1975) and NICOLL (1995).

Phylum: Chordata BATESON 1886
Class: Conodonta EICHENBERG 1930
sensu CLARK 1981

Genus *Phragmodus* BRANSON & MEHL 1933.
Type species: *Phragmodus primus* BRANSON & MEHL 1933.

Phragmodus flexuosus MOSKALENKO 1973
Plate 7.4, fig. 1, Plate 5, 1–7, Plate 7.6, Figs. 1–3, 5–8, Plate 7.7, figs. 1–5.

Synonymy:

1969 *Phragmodus undatus* (BRANSON & MEHL), ETHINGTON & SCHUMACHER, 153. 72, Pl. 67, fig. 15.

1969 *Cyrtoniodus flexuosus* (BRANSON & MEHL), ETHINGTON & SCHUMACHER, 155, 459, Pl. 67, fig. 11.

1971 *Phragmodus* sp. A SWEET et al.; Pl. 2, figs. 3–6.

1971 *Phragmodus* sp. MOSKALENKO, p. 81, Pl. 13, fig. 5.

1971 *Phragmodus* sp. MOSKALENKO, p. 88, Pl. 13, fig. 4.

1971 *Subcordylodus sinuatus* (STAUFFER); MOSKALENKO, p. 88, Pl. 13, fig. 4.

1972 *Phragmodus* sp. nov. MOSKALENKO, fig. 1.

1973a *Phragmodus flexuosus* MOSKALENKO, p. 73–74, Pl. 11, figs. 4–6.

1973b *Phragmodus flexuosus* MOSKALENKO, p. 89, Pl. 18, fig. 6.

1973 *Subcordylodus sinuatus* (STAUFFER); MOSKALENKO, p. 80–81, Pl. 12, figs. 7–9.

1978 ?*Phragmodus flexuosus* (MOSKALENKO); BERGSTRÖM, Pl. 79, fig. 16.

1979 (1978) *Phragmodus flexuosus symmetricus* (MOSKALENKO); n. sub. sp., TIPNIS, et al., p. 60–61, Pl. V, figs. 6–9.

1981 ?*Phragmodus flexuosus* (MOSKALENKO); ETHINGTON & CLARK, p. 79–82, Pl. 9, figs. 2–7.

1983 ?*Phragmodus flexuosus* (MOSKALENKO); MOSKALENKO, Text–figs. 4A–4D.

1987 ?*Phragmodus flexuosus* (MOSKALENKO); Morphotype A, BAUER, p. 24, 25, Pl. 3, figs. 10, 14, 18, 20, 24, Text–fig. 8A.

1987 ?*Phragmodus flexuosus* (MOSKALENKO); COPELAND, et al., p. 7, Pl. 1.3, figs. 4, 5, 7–13.

1989 *Phragmodus flexuosus* (MOSKALENKO); BAUER, p. 367–368, Fig. 5, 30–33.

1999 *Phragmodus flexuosus* (MOSKALENKO); PERCIVAL, et al., p. 17, fig. 6, figs. 8.14, fig. 8.15.

Remarks:

Types of elements.

M element (Cyrtoniodontform).

The denticles on the posterior process tend to be compressed.

S elements (Phragmodontiform).

The Sa element has a symmetrical anterior lateral process on the cusp. The anterior process is slightly to prominently arched with a sinuous posterior process. The denticles near the main cusp are shorter and narrower. The posterior denticle is long, broad and conspicuous.

The Sb element has one adenticulated lateral process farther forward on the element. The process is slightly arched and slightly sinuous.

The Sc elements (Cordylodiform) have an anterior process is laterally deflected and flange like. The posterior process is not arched. The denticles are short and the posterior denticle is long.

Pa and Pb elements. (Dichognathiform).

The P elements exhibit an angle of between 10°–20° between the lateral adentated anterior process. The shorter, lateral process forms an angle of 70°–80° to the anterior process (ZIEGLER, Ed. 1981, p. 255).

The Assemblage Series of *Phragmodus flexuosus* MOSKALENKO is composed of seximembrate elements. These are illustrated in LESLIE & BERGSTRÖM (1995, p. 972) and in Fig. 7.3.

RARING (1972, p. 102) noted that the elements of *Phragmodus* sp. nov. (=*P. flexuosus*

SWEET had a more flexed posterior process which was twisted along its axis and deflected aborally.

Age:
ZIEGLER, (1981) noted that *Phragmodus flexuosus* MOSKALENKO ranged from the early Middle Ordovician to the upper Darriwilian.

LESLIE & BERGSTRÖM (1995, p. 969) noted that *Phragmodus flexuosus* MOSKALENKO had a short time range of Uppermost Whiterockian to Middle Mohawkian.

Specimens from the Volginsky Beds ranged from Upper Darriwilian to lower Gisbornian (MOSKALENKO 1972, 1973).

A conodont fauna containing *Phragmodus flexuosus* MOSKALENKO and *Periodon aculeata* HADDING from the Wahringa Limestone Member of Central NSW, Australia was given an age of Darriwilian, (Da 2 to Gisbornian, G1) (PERCIVAL(et al., 1999).

A conodont fauna from the Ugbrook Member at Mole Creek, Tasmania containing *Phragmodus flexuosus* MOSKALENKO had and equivalent range to Faunas 5 to 6 (Upper *E. suecicus* through to the *P. variabilis* Zone) in North America.

BURRETT, (In: CLARK & COOK 1983, fig.12.30) recorded *Phragmodus flexuosus* MOSKALENKO within the *Phragmodus flexuosus* chronozone of SWEET (uppermost Whiterockian to the lowermost part of the Blackriveran Stage, (Lowest *Pygodus serrus* Zone to the top of the *Pygodus anserinus* Zone).

The species has been recorded in the (Darriwilian) in Tasmania.

Specimens:
M elements.
One M element from Ida Bay southern Tasmania.
One M element from the Lower Limestone Member of the Florentine Valley.

S elements.
One S element from the Florentine Valley, Tasmania.
One Sa element from the Lower Limestone Member of the Florentine Valley.
Four Sa element from Mole Creek Limestones.
One Sa? element from Mole Creek Limestones.
One Sa? element from the Florentine Valley, Tasmania.

One Sa element from Bub's Hill. Tasmania.
One Sb element from Mole Creek Limestones.
One Sa element from Ida Bay, southern Tasmania.
One Sb? element from Ida Bay, southern Tasmania.
Two Sc elements from the Florentine Valley, Tasmania.
One Sc element from Bub's Hill Tasmania.

P elements.
One Pa? element from the limestones near Zeehan, western Tasmania.
One Pa ? element from Mole Creek limestones.
One Pb element from limestones at Ida Bay, southern Tasmania.

Phragmodus tasmaniensis n. sp.
Plate 7.4. fig. 2, Plate 7.8, figs 1–7, Plate 7.9, figs. 1–6.

Diagnosis:
The elements of *Phragmodus tasmaniensis* n. sp. have three main forms. The S elements (Phragmodontiform) are short, slightly flexed, strongly arched and has four to six denticles. Some S elements have from two to up to five denticles arching together and appear to be fused for at least two thirds of their lengths. There are fewer denticles on the posterior processes of the S elements. The two larger, broken denticles in Plate 7.8, fig. 7 indicate that the basal cavity extends deeply into at least two denticles. The S elements are shorter than S elements of *Phragmodus flexuosus* MOSKALENKO.

The element in Plate 9.2, fig. 2 has been tentatively diagnosed as a possible Sd? element of *Phragmodus flexuosus* MOSKALENKO. The element is more elongated and the lateral denticles arch downwards at the end of the anterior lateral process. The Tasmanian element possesses a distinct carinae on the side of the main cusp and the denticles on the posterior lateral process arch downwards.

The M elements (Cyrtoniodontiform) reported from Tasmania by BURRETT (1978, unpub., Fig. 54, C) have a typical oistodiform lip around the basal cavity with a small denticle protruding from the posterobasal edge of the element. (See Fig. 7.3, Diag. No. 43). The cusp of the element is elliptical and broad in cross section and the anterior and posterior margins are sharp edged. The M? element in Plate 7.9, fig. 6 is tentatively referred to as an element of *Phragmodus tasmaniensis* n. sp. The first denticles is much shorter than the same element of *Phragmodus flexuosus* MOSKALENKO (See Fig. 7.3, Diag. No. 37, this study). The other two denticles are longer and are more separated.

The upright denticles on P elements are situated on a long arching bar. There may by up to six denticles on the anterior and posterior sides of the element. The basal cavity is long and extends to each end of the elements as a groove. The cavity also extends upwards under the main denticle.

Age:

Phragmodus tasmaniensis n. sp. reported from Tasmania was of a similar age to Fauna 7 of North America (SWEET 1971). The species ranges from the base of the *E. variabilis* Zone (Uppermost Arenig) to the Mid Caradoc (middle of the *Phragmodus undatus* Zone). The age range of *Phragmodus tasmaniensis* n. sp. recorded at Ida Bay in southern Tasmania and the Florentine Valley may extend into the Middle Eastonian.

Specimens:

M elements.

One M element has been recorded from Ida Bay, Tasmania.

One M element has been recorded from the Lower Limestone Member of the Florentine Valley.

S elements.

Four Sa elements have been recorded from Mole Creek, Tasmania.

Two Sa elements have been recorded from Ida Bay, Tasmania.

One Sa element from the Lower Limestone Member in the Florentine Valley.

One Sa? element has been recorded from Mole Creek, Tasmania.

One Sa element from Zeehan.

One Sb ? elements has been recorded from Ida Bay, southern Tasmania.

One Sa? element has been recorded from the Florentine Valley, Tasmania.

One Sb element has been recorded from Mole Creek, Tasmania.

Two Sc elements have been recorded from the Florentine Valley, Tasmania.

P elements.

One Pa? element has been recovered from Mole Creek, Tasmania.

One Pa? element has been recorded from Zeehan, western Tasmania.

One Pb element has been recorded from Ida Bay, southern Tasmania.

Phragmodus undatus BRANSON & MEHL 1966.

Plate 7.1, figs. 1–8, Plate 7.2, figs. 1–8, Plate 7.3, figs. 1–7, Plate 7. 6, fig. 4.

Synonymy:

1933b *Phragmodus primus* BRANSON & MEHL; p. 98-99, Pl. 6, figs 26.

1933c *Phragmodus undatus* BRANSON & MEHL; p. 115–116, Pl. 8, figs. 22–26.

1933c *Dichognathus brevis* BRANSON & MEHL, p. 113, pl. 9, figs. 24–26.

1933 *Dichognathus brevis* BRANSON & MEHL; *idem.*, p. 113, Pl. 9, figs. 24–26 .

1933 *Dichognathus typica* BRANSON & MEHL; *idem.*, 113–114, Pl. 9, figs. 27-29

1933 *Oistodus abundans* BRANSON & MEHL; *idem.*, p. 109, Pl .9, figs. 27–29.

1960? *Phragmodus undatus* (BRANSON & MEHL); PULSE & SWEET, p. 257, 258, Pl. 37, figs. 18 and 19 only.

1966 *Phragmodus undatus* (BRANSON & MEHL); WEBERS, p. 41, Pl. 10, figs. 10, 11, 13, 15.

1966 *Phragmodus undatus* (BRANSON & MEHL); BERGSTRÖM & SWEET, p. 369–372, figs. 13–20.

1966 *Phragmodus undatus* (BRANSON & MEHL); PHILIP, p. 112, figs. 1–5.

1967 *Phragmodus undatus* (BRANSON & MEHL); ANDREWS, p. 896–897, Pl. 114, fig. 10.

1981 *Phragmodus undatus* (BRANSON & MEHL); NOWLAN & BARNES, p. 21, Pl. 4, figs. 1–11, 13.

1981b *Phragmodus undatus* (BRANSON & MEHL); NOWLAN, p. 278, 282, Pl. 1, figs. 18, 20–24, Pl. 3, fig. 4.

1988 *Phragmodus undatus* (BRANSON & MEHL); PALMIERI, p. 24, Pl. 4, figs. 18–23, Pl. 6, figs. 2–5, 7–12, Pl. 7, figs. 1–8, 11, 12.

1988 *Phragmodus undatus* (BRANSON & MEHL); NOWLAN et al., p. 26–27, Pl. 10, figs. 1–3, 6, 7. (*cum syn.*).

1988 *Phragmodus undatus* (BRANSON & MEHL); MCCRACKEN & NOWLAN, p. 1889, Pl. 3, figs. 10–12.

1990 *Phragmodus undatus* (BRANSON & MEHL); BERGSTRÖM, Pl. 4, figs. 9–10.

1990 *Phragmodus undatus* (BRANSON & MEHL); POHLER & ORCHARD, Pl. 1, figs. 12, 13.

1990 *Phragmodus undatus* (BRANSON & MEHL); AN et al. p. 20, 21, 107, 123? Pl. 10, figs. 19–21.

1995 *Phragmodus undatus* (BRANSON & MEHL); TROTTER & WEBBY, p. 485, Pl. 6, figs. 2–11, (1 and 12)?

1995 *Phragmodus undatus* (BRANSON & MEHL); ZHEN & WEBBY. p. 284, Pl. 4, fig. 5.

1995 *Phragmodus undatus* (BRANSON & MEHL); LESLIE & BERGSTRÖM, p. 970–973, Fig. 4, 1–7, and 8–13.

1999 *Phragmodus undatus* ? (BRANSON & MEHL); PERCIVAL et al., p. 19, 22.

2003 *Phragmodus undatus* (BRANSON & MEHL); PYLE & BARNES, p. 149, fig. 3, Figs. 14.11. 14. 12, 14.31, 14.32.

Remarks:

A complete Transition Series of elements of *Phragmodus undatus* BRANSON & MEHL has been recovered from from Tasmania. The P elements of *Phragmodus undatus* BRANSON & MEHL have pastinate Pa elements. The S elements *Phragmodus undatus* BRANSON & MEHL tend to be more sinuous than elements of *Phragmodus cognitus* STAUFFER (SWEET 1982, p. 1044).

A proposed model of the architecture of *Phragmodus undatus* BRANSON & MEHL is shown in Fig. 7.4.

Age:

Phragmodus undatus BRANSON & MEHL ranges from Middle to the Upper Ordovician. POHLER & ORCHARD (1990) considered *Phragmodus undatus* to be a North Atlantic zonal index fossil for the North American Mid Continent region.

LESLIE & BERGSTRÖM (1995, p. 969) gave an age of Middle Mohawkian to Upper Cincinnati for *Phragmodus undatus*. The top of the *P. undatus* Zone is defined by the first appearance of *Plectodina tenuis.*

BURRETT (1978, unpub.) recorded the first appearance of *Phragmodus undatus* in the Chudleigh Limestone (base of the Standard Hill Formation) and the Den Formation at the base of Fauna 8 and appeared in all faunas through to Fauna 10 (North America Conodont Fauna). This ranges from the base of the *Phragmodus undatus* Zone to the Upper *A. superbus* Conodont Zone (SWEET 1971, p. 175).

BURRETT, (In: CLARK & COOK 1983) indicated that *Phragmodus undatus* BRANSON & MEHL occupied the *Phragmodus undatus* chronozone (Lower Rocklandian to Maysvillian) in Tasmania. Fig. 7.7 shows the distribution and the range of *Phragmodus undatus* BRANSON & MEHL in different locations.

Phragmodus undatus BRANSON & MEHL has been recently reported from the Skoki Formation (*P. aculeata* Zone) and the Beaverfoot Formation (*P. undatus* Zone) (PYLE & BARNES 2003).

Specimens.

The following elements were recovered from Ordovician rocks in Tasmania.

M elements.

One M element has been recovered from Ida Bay, Tasmania.

S elements.

One S element from Zeehan, western Tasmania.

One S element from Mole Creek. Tasmania.

Two Sa? elements from Mole Creek, Tasmania.

Two Sa elements from Mole Creek.

Two Sb elements from Mole Creek, Tasmania.

One Sb element from the Den Member, Mole Creek, Tasmania.

Two Sc elements from Mole Creek, Tasmania.

Two Sb elements from The Den Member, Mole Creek Tasmania.

Four Sc elements from The Den Member, Mole Creek, Tasmania.

Two Sc elements from Ida Bay, southern Tasmania.

P elements.

One P element from Mole Creek, Tasmania.

One Pa? element from Mole Creek, Tasmania.

One Pa element from the Den Limestone Member.

One Pa element from the Lower Limestone Member of the Florentine Valley.

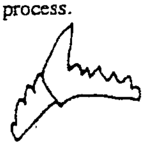
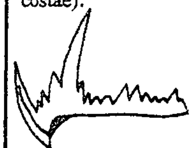
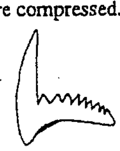
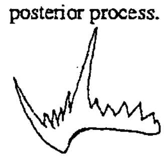
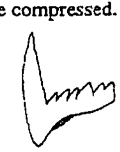
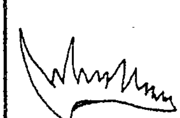
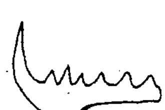
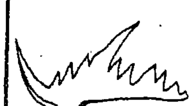
POSITION / SPECIES	Pa	Pb	M	Sc	Sb	Sa
P. undatus	Pastinate with compressed denticulate lateral and posterior processes and an adenticulate anterior process.  (dichognathiform)	Pastinate with compressed denticulate lateral and posterior processes and an adenticulate anterior process.  (dichognathiform)	Geniculate coniform with a compressed cusp that is anteriorly and posteriorly keeled.  (oistodontiform)	Bipennate with one enlarged denticle at the maximum inflection of a sinuous posterior process.  (phragmodontiform)	Like Sc but tertiopedate with adenticulate inner and outer lateral processes (or costae).  (phragmodontiform)	Like Sc but alate with adenticulate inner and outer lateral processes (or costae).  (phragmodontiform)
P. cognitus	Anguiate with compressed denticulate anterior and posterior processes.  (ozarkodiniform)	Pastinate with compressed denticulate lateral and posterior processes and an adenticulate anterior process.  (dichognathiform)	Dolabrate with a compressed anteriorly and posteriorly keeled cusp. Denticles on posterior process are compressed.  (cyrtoniodontiform)	Bipennate with one enlarged denticle at the maximum inflection of a relatively straight, distally unbowed posterior process.  (phragmodontiform)	Like Sc but tertiopedate with adenticulate inner and outer lateral processes (or costae).  (phragmodontiform)	Like Sc but alate with adenticulate inner and outer lateral processes (or costae).  (phragmodontiform)
P. inflexus	Pastinate with compressed denticulate lateral and posterior processes and a single denticle on the anterior process.  (dichognathiform)	Pastinate with compressed denticulate lateral and posterior processes and an adenticulate anterior process.  (dichognathiform)	Dolabrate with a compressed anteriorly and posteriorly keeled cusp. Denticles on posterior process are compressed.  (cyrtoniodontiform)	Bipennate with one enlarged denticle at the maximum inflection of a sinuous posterior process.  (phragmodontiform)	Like Sc but tertiopedate with adenticulate inner and outer lateral processes (or costae).  (phragmodontiform)	Like Sc but alate with adenticulate inner and outer lateral processes (or costae).  (phragmodontiform)
P. flexuosus	Pastinate with compressed denticulate lateral and posterior processes and an adenticulate anterior process.  (dichognathiform)	Pastinate with compressed denticulate lateral and posterior processes and an adenticulate anterior process.  (dichognathiform)	Dolabrate with a compressed anteriorly and posteriorly keeled cusp. Denticles on posterior process are compressed.  (cyrtoniodontiform)	Dolabrate with a faintly sinuous posterior process.  (cordylodontiform)	Tertiopedate with adenticulate inner and outer lateral processes (or costae) and one enlarged denticle at the maximum inflection of the posterior process.  (phragmodontiform)	Alate with adenticulate inner and outer lateral processes (or costae) and one enlarged denticle at the maximum inflection of the posterior process.  (phragmodontiform)

Fig. 7.9. Summary of the characteristics used to separate *Phragmodus* species Nomenclature of SWEET & SCHONLAUB (1975) and SWEET (1981b) are used as well as the form genera names.
Figures from LESLIE, S.A., & BERGSTRÖM (1995).

Plate 7.1.

Elements of *Phragmodus undatus* BRANSON & MEHL from Tasmania.

Figs. 1–8: *Phragmodus undatus* BRANSON & MEHL.

Fig. 1. Lateral view of a Pa element from The Den, Mole Creek. X 125. TUGD128565

Fig. 2. Lateral view of a Pa element from the Lower Limestone Member Florentine Valley, X 165. TUGD128566

Fig. 3. Lateral view of an Sb element from The Den, Mole Creek. X 125. TUGD128567

Fig. 4. Lateral view of an Sc element from Mole Creek. X105. TUGD128568

Fig. 5. Lateral view of an S element. from Mole Creek. X 170. TUGD128569

Fig. 6. Lateral view of an Sc element from Ida Bay, Tasmania. X 135. TUGD128570

Fig. 7. Lateral view of an Sa element from Mole Creek. X 170. TUGD128571

Fig. 8. Lateral view of an Sc element from Ida Bay, X 135. TUGD128572

Plate 1

Plate 7.2.

Figs. 1–8. *Phragmodus undatus* BRANSON & MEHL

Fig. 1. Lateral view of an Sc element from The Den, Mole Creek. X160. TUGD128573

Fig. 2. Lateral view of an Sc element from The Den, Mole Creek. X 220. TUGD128574

Fig. 3. Lateral view of an Sb element from The Den, Mole Creek. X 160. TUGD128575

Fig. 4. Lateral view of an Sb element from The Den, Mole Creek. X 160. TUGD128576

Fig. 5. Lateral view of an Sc element from The Den, Mole Creek. X 160. TUGD128577

Fig. 6. Lateral view of an Sc element from The Den, Mole Creek. X 195. TUGD128578

Fig. 7. Lateral view of an Sc element from Mole Creek. X 125. TUGD128579

Fig. 8. Lateral view of an Sa? element from Mole Creek. X 150. TUGD128580


Plate 2
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7
8

Plate 7.3.

Figs. 1–7. *Phragmodus undatus* BRANSON & MEHL

Fig.1. Lateral view of an Sa element. from Mole Creek. X 105.	TUGD128581
Fig. 2. Lateral view of an Sb element from Mole Creek. X 130.	TUGD128582
Fig. 3. Lateral view of an Sb element from Mole Creek. X 130.	TUGD128583
Fig. 4. Lateral view of an Sa? element from Mole Creek. X 155.	TUGD128584
Fig. 5. Lateral view of an Pa? element from Mole Creek. X 130.	TUGD128585
Fig. 6. Lateral view of an M element from Ida Bay, X 100.	TUGD128586
Fig. 7. Lateral view of an P element from Mole Creek. X 160.	TUGD128587


Plate 3
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7

Plate 7.4.

Fig. 1. *Phragmodus flexuosus* MOSKALENKO

Fig. 1. Lateral view of an Sa element from Mole Creek,Tasmania.
X 90. TUGD128588

Fig. 2. *Phragmodus tasmaniensis* n. sp.

Fig. 2. Sa element of *Phragmodus tasmaniensis* n. sp. from Zeehan, Tasmania.
X 145. TUGD128589

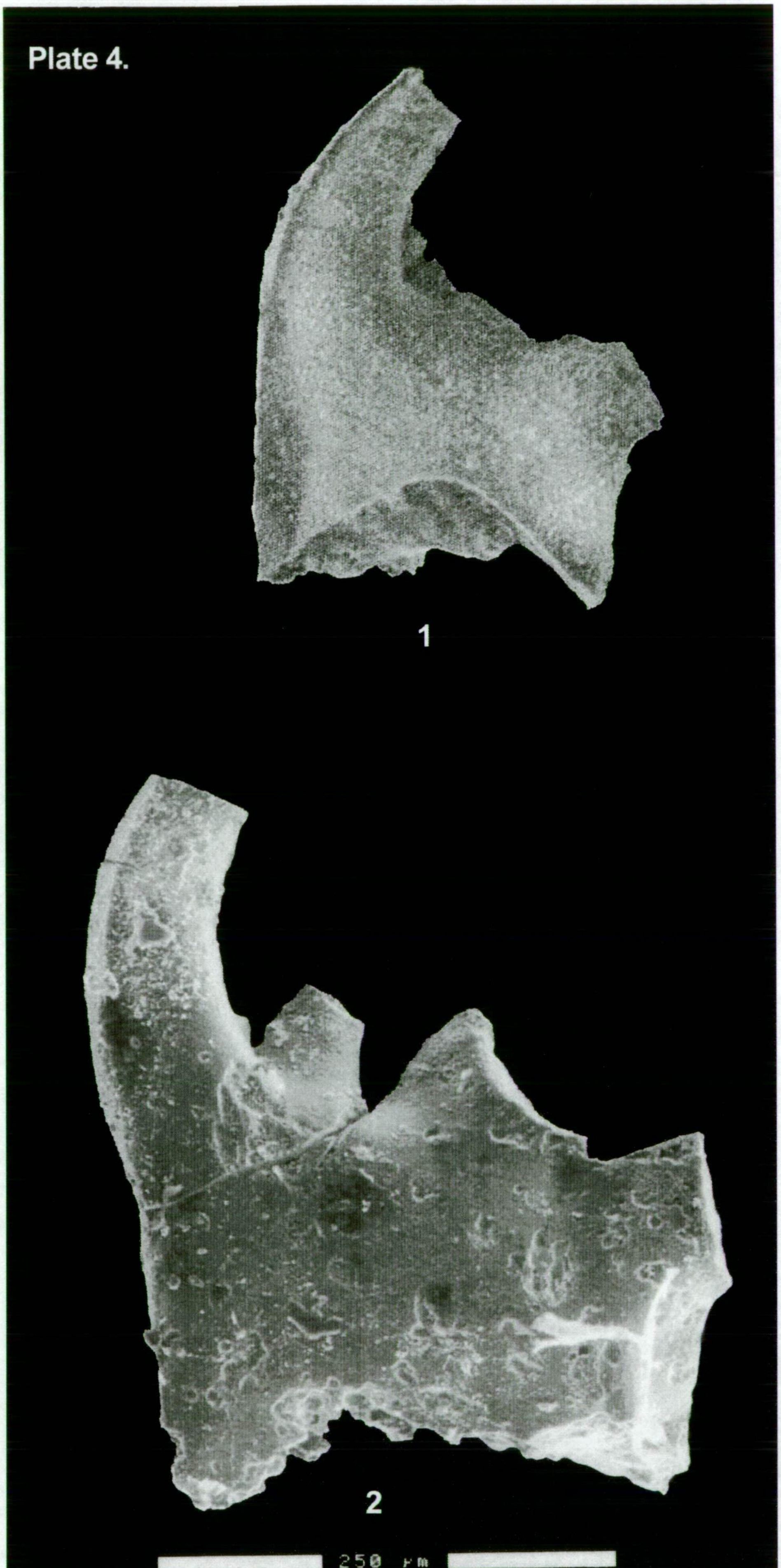
Plate 4.
1
2
250 µm

Plate 7.5.

Figs. 1–7. *Phragmodus flexuosus* MOSKALENKO

Fig. 1. Lateral view of a recrystallised Sc element from Mole Creek, Tasmania. X 200. TUGD128590

Fig. 2. Lateral view of an Sa? element from Mole Creek, Tasmania. X 155 TUGD128591

Fig. 3. Lateral view of an Sb? element from Ida Bay, Tasmania. X 125. TUGD128593

Fig. 4. Lateral view of a Pb element from Ida Bay, Tasmania. X 120. TUGD128594

Fig. 5. Lateral view of an Sc element from Bub's Hill, Tasmania. X 105. TUGD128595

Fig. 6. Lateral view of an Sb element from Mole Creek, Tasmania. Denticles have been replaced by apatite crystals. X 240. TUGD128596

Fig. 7. Lateral view of a Pa? element from Zeehan, X 195. TUGD128597

Plate 5
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7

Plate 7.6.

Figs. 1–3. *Phragmodus flexuosus* MOSKALENKO

Fig.1. Lateral view of an Sa element from Ida Bay, Tasmania. X 215. TUGD128598

Fig. 2. Lateral view of an Sa element from Ida Bay, Tasmania. X 160. TUGD128599

Fig. 3. Lateral view of an Sc element from Mole Creek, Tasmania. X 200. TUGD128600

Fig. 4. *Phragmodus undatus* ? BRANSON & MEHL, cf. *Phragmodus flexuosus* MOSKALENKO.
Lateral view of an Sa element from Bub's Hill, Tasmania. X 200. TUGD128601

Figs. 5–8. *Phragmodus flexuosus* MOSKALENKO

Fig .5. Lateral view of an Sa element from Mole Creek, Tasmania. X 170. TUGD128602

Fig. 6. Lateral view of an Sb element from Bub's Hill, Tasmania. X 145. TUGD128603

Fig. 7. Lateral view of a Pa? element from Mole Creek, Tasmania. X 155. TUGD128604

Fig. 8. Lateral view of an Sa element from Mole Creek, Tasmania. X 150. TUGD128605

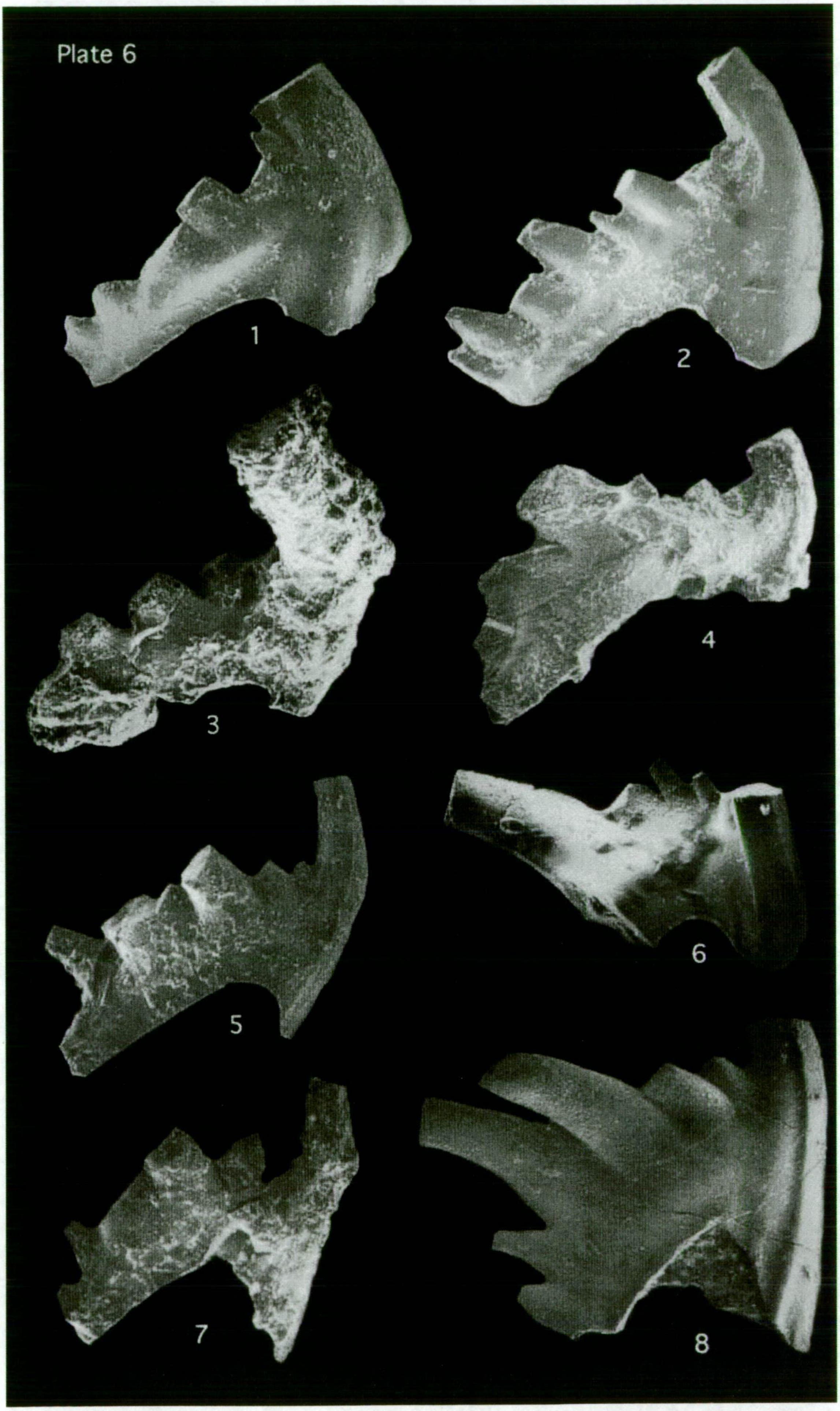
Plate 6
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2
3
4
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8

Fig. 7.7.

Figs. 1–5. *Phragmodus flexuosus* MOSKALENKO

Fig. 1. Lateral view of an Sa element from the Lower Limestone Member of the Florentine Valley. X 90. TUGD128606

Fig. 2. Lateral view of an Sa? element from Mole Creek, Tasmania.X 195. TUGD128607

Fig. 3. Lateral view of an Sa element. from Mole Creek, Tasmania. X 210. TUGD128608

Fig. 4. Lateral view of an M element from Ida Bay, Tasmania. X 170, TUGD128609

Fig. 5. Lateral view of a M element from the Lower Limestone Member of the Florentine Valley. X 110. TUGD128610

Plate 7

Plate 7.8.

Figs. 1–8. *Phragmodus tasmaniensis* n. sp.

Fig. 1. Lateral view of an Sa element from Mole Creek, Tasmania. X 105. TUGD128611

Fig. 2. Lateral view of an Sc element, Ida Bay, Tasmania. X 150. TUGD128612

Fig. 3. Lateral view of an Sb element, Mole Creek, Tasmania. X135. TUGD128613

Fig. 4. Lateral view of an Sb element from Ida Bay, Tasmania. X 125. TUGD128614

Fig. 5. Lateral view of an Sa element from the Lower Limestone Member, Florentine Valley, Tasmania. X 165. TUGD128615

Fig. 6. Lateral view of an Sa from Mole Creek, Tasmania. X 145. TUGD128616

Fig. 7. Lateral view of an Sc element from Mole Creek, Tasmania. X 160. TUGD128617

Plate 8

Plate 7.9.

Fig. 1. *Phragmodus undatus* BRANSON & MEHL

Fig. 1. Lateral view of an S element from Zeehan, Tasmania. X 160. TUGD128618

Fig. 2. *Phragmodus tasmaniensis* n. sp.

Fig.2. Lateral view of an Sd? element from Ida Bay, Tasmania. X 160. TUGD128619

Figs. 3–6. *Phragmodus tasmaniensis* n. sp.

Fig. 3. Lateral view of an Sa element from Mole Creek, Tasmania. X 170. TUGD128620

Fig. 4. Lateral view of an Sa element, Mole Creek, Tasmania. X 190. TUGD128621

Fig. 5. Lateral view of an Sa element, from The Den, Tasmania. X 125. TUGD128622

Fig. 6. Lateral view of an M element from Mole Creek, Tasmania. X 190. TUGD128623

Plate 9

Chapter 8

The Greater Gondwana distribution of the Ordovician (Whiterockian) conodont *Panderodus nogamii* (LEE) 1975.

Introduction.

Specimens referable to *Scolopodus nogamii* LEE (1975) have been studied as part of an extensive review of the Ordovician conodont faunas of Tasmania, Thailand and Malaysia. The species *Scolopodus nogamii* LEE was first described by LEE (1975) from the Mandal Formation of North Korea. From our studies it is clear that specimens referable to *Scolopodus nogamii* LEE have been recorded from the Middle Ordovician of Argentina, Australia, North and South Korea, Thailand, Malaysia and China (Fig. 8.1).

The definitive characteristics of the elements from Malaysia, Thailand and Tasmania and a review of the literature suggests that *Scolopodus nogamii* LEE should now be reassigned to the genus *Panderodus* ETHINGTON.

Palaeogeographic Distribution of *Panderodus nogamii* (LEE).

Panderodus nogamii (LEE) has a wide distribution in the continental blocks that formed Gondwana during the Ordovician. The type species *Scolopodus nogamii* LEE was originally reported from the Mandal Formation of North Korea by LEE (1975) (Fig. 8.1).

ALBANESI et al., (1995) recorded the species *"Scolopodus" nogamii* LEE =*Panderodus nogamii* (LEE) from the Yerba Loca Formation in the Precordillera of Argentina.

The conodont elements from the Nora Formation, Toko Range in western Queensland which are illustrated in HILL et al., (1969, Plate OVII, figs. 13, 15) closely resemble the longer, more slender elements of elements of *Protopanderodus nogamii* (LEE) from the Canning Basin Australia (WATSON 1988, Pl. 3. 1a, 1b, 6a, 6b). The elements possess the longitudinal, centrally placed furrow and the long striations on the lateral faces. They are very similar to the Sc elements of *Panderodus nogamii* (LEE) from southeast Asia and Tasmania but are not as robust.

Panderodus nogamii (LEE) has been described from the Middle Ordovician Standard Hill Formation and the Ugbrook Formation at Mole Creek, the Karmberg and Cashions Creek Formations, Florentine Valley, and from Zeehan, Tasmania (BURRETT Ph.D. thesis, 1978

Fig. 8.1. Distribution of the gastropod *Peelerophon oehlerti* (BERGERON), the trilobite *Asaphopsoides* sp. and the conodont *Panderodus nogamii* (LEE) around Greater Gondwana during the Early to Middle Ordovician.
After WHITTINGTON & HUGHES (1972,1973), JELL et al., (1984), JELL & STAIT (1985), BURRETT & STAIT (1985), BURRETT et al, (1990), and LAURIE & BURRETT (1992).

Locations sites

1. Argentina.
2. Langkawi Islands (Malaysia), and Ko Tarutao, and mainland Thailand.
3. The Canning Basin, Western Australia.
4. Amadeus Basin, Central Australia.
5. Nora Formation, Georgina Basin. Western Queensland.
6. Gordon Sub Group, Tasmania.
7. Yangtze Region, South China.
8. Southern France

The approximate position of the Occidental Terrane is after CAÑAS (1995b), RAMOS (1995), KELLER (1997) and KELLER et al. (1998).

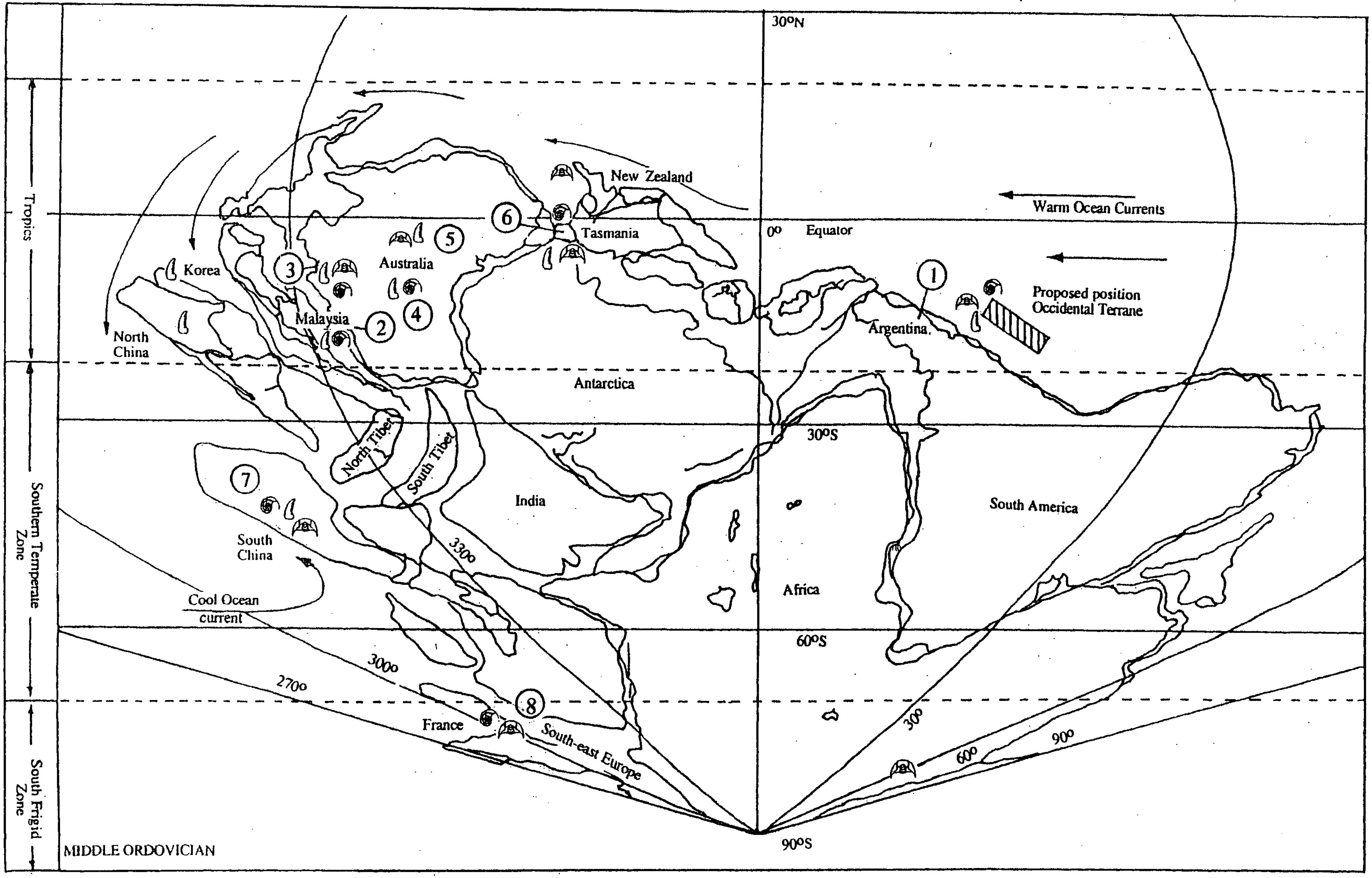
The palaeomagnetic data used to construct the map was obtained from FANG et al., (1990), ZHAO et al., (1992), RAPALINI & TARLING (1993), ZHAO et al., (1996), and HUANG et al., (1999).

Key.


Asaphopsoides HUPÉ


Peelerophon oehlerti (BERGERON).


Panderodus nogamii (LEE).


30°N
Tropics
Southern Temperate Zone
South Frigid Zone
New Zealand
Warm Ocean Currents
Tasmania
0° Equator
Australia
Korea
Malaysia
North China
Proposed position Occidental Terrane
Argentina.
Antarctica
30°S
North Tibet
South Tibet
India
South America
South China
Africa
Cool Ocean current
330°
300°
270°
60°S
France
South-east Europe
30°
60°
90°
90°S
MIDDLE ORDOVICIAN
1
2
3
4
5
6
7
8

unpub., and BURRETT et al., 1989). Additional specimens of *Panderodus nogamii* (LEE) of Middle Ordovician age have been reported from Ida Bay, Loongana, Felix Curtain Road within the Florentine Valley and the Railton limestone quarry in northern Tasmania. (Figs. 8.4 and 8.5.).

Recently *Panderodus nogamii* (LEE) has also been reported from the Lower Stokes Siltstone, Amadeus Basin, Central Australia (ZHANG et al., (2000).

Scolopodus nogamii LEE has been reported from the Fengfeng Formation (*Pygodus serra* to middle *A. tvaerensis*) of North China (ZENG et al., 1983) and from within the Miaopo Stage (Darriwilian) of South China (AN et al., 1985)

LAURIE & BURRETT (1992) recorded *Protopanderodus nogamii* (LEE) from the Setul Limestone Langkawi Islands, Malaysia. (G to K lithostratigraphic units of WONGWANICH et al., 1983). *Panderodus nogamii* (LEE) also occurs within the Section AB3 (lithostratigraphic unit I) of WONGWANICH et. al., (1983) on Palau Langgon, Malaysia (Chapter 3, herein, and Fig. 8.2).

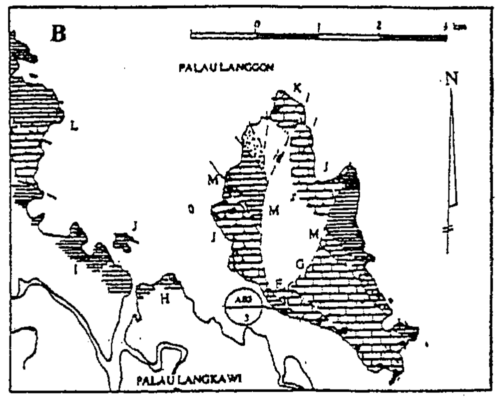
Panderodus nogamii (LEE) has recently been reported from the Malaka Formation, the La Nga Formation, Ko Tarutao and within the Ordovician sediments of the Thung Song Group of mainland Thailand (Herein and Fig. 8.7.)

Biostratigraphical Correlation.
The correlation of the strata and the age of the elements erected as species of *Panderodus nogamii* (LEE) are tabled in Tables 8.1, and 8.2.

LAURIE & BURRETT (1992) and (CANTRILL & BURRETT 2002, in press) recorded *Panderodus nogamii* (LEE) ranging from the Middle Arenig to the top of the Darriwilian Stage in Ordovician limestones of Tasmania. The specimen of *Panderodus nogamii* (LEE) from the Railton Quarry is considered to be Darriwilian in age. The limestones cropping out in the Cashions Creek Formation, Florentine Valley, contain elements of *Panderodus nogamii* (LEE) (*P. anserinus* to the earlier *E. variabilis* Assemblage Zone).

WATSON (1988) recorded *Protopanderodus nogamii* (LEE) in Middle Darriwilian (Da3) Stage ranging from the Upper ?*Eoplacognathus variabilis* Zone through to the upper *Eoplacognathus seucicus* Assemblage Zone in the Canning Basin, Western Australia.

Scolopodus nogamii =*Panderodus nogamii* (LEE) was reported from the Fenfeng Formation (Darriwilian Stage) in North China by AN et al., (1983) and ZENG et al., (1983)



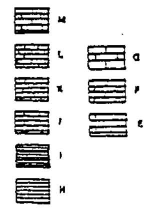


Fig. 8.2. Study Area **B**.

Palau Langgon showing the location of Section AB3. Lithological units are WONGWANICH et al. (1982), WYATT (1983), LAURIE & BURRETT (1992).

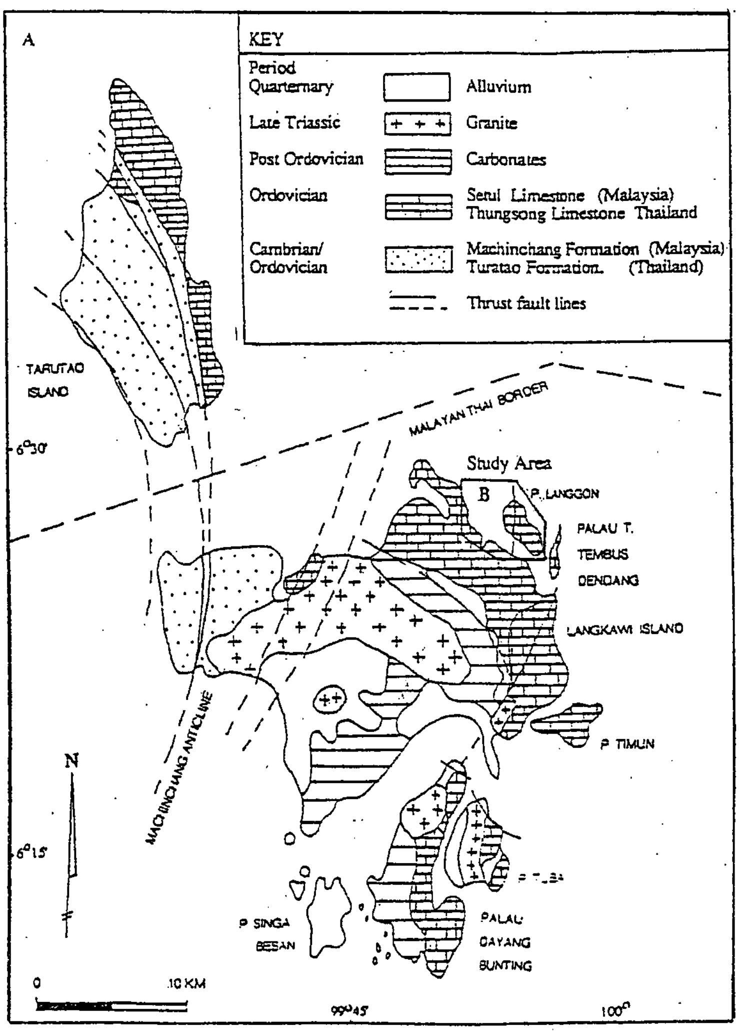
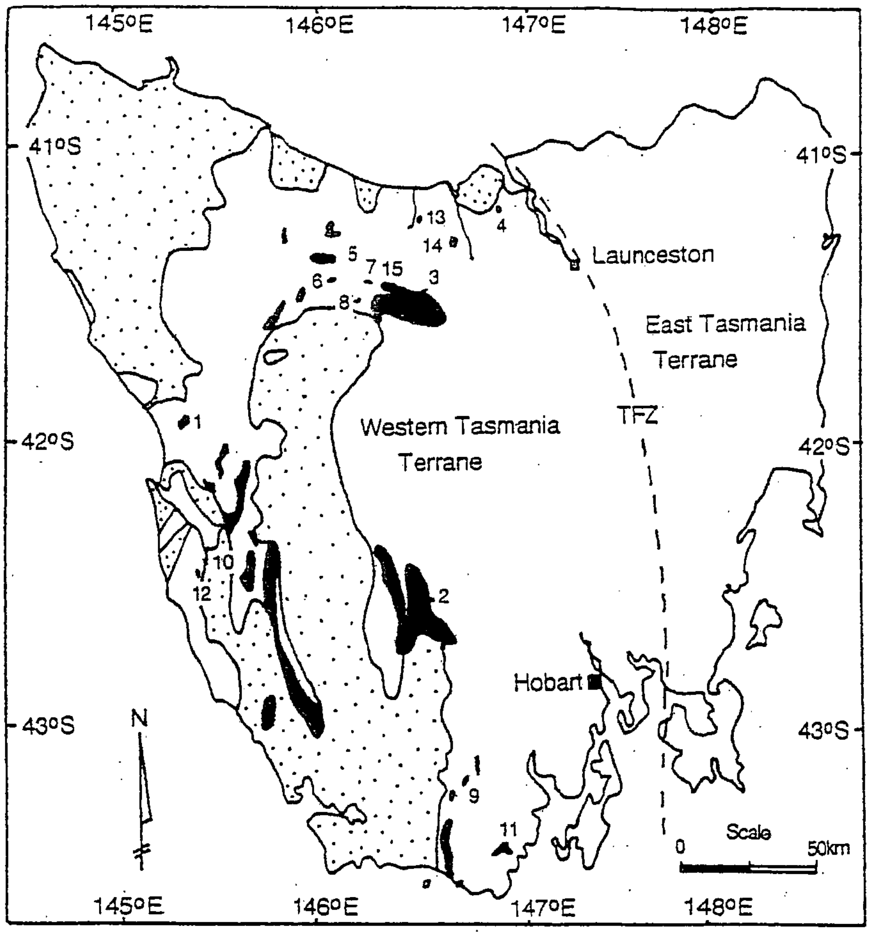


Fig. 8.3. Map **A**. Map of the Langkawi Islands showing the location of Study Area **B** on Palau Langgon.

The geology of Tarutao Island (Thailand) and the Langkawi Islands are also shown.

After KIMURA & JONES (1967) and STAIT et al. (1987).



Key:

1. Zeehan
2. Cashions Creek Fm. Florentine Valley.
3. Mole Creek
4. Flowery Gully, Beaconsfield.
5. Loongana
6. Moina
7. Claude Creek
8. Lorinna
9. Judd's Cavern
10. Gordon–Franklin River.
11. Mystery Creek Caves.
12. Olga River–Gordon River
13. Eugenana–Melrose, Paloona.
14. Railton.
15. Liena

Major areas of Gordon Group Carbonates. Ordovician.

Main areas of Proterozoic rocks.

Fig. 8.4. Map showing the distribution of Gordon Group (Lower Ordovician) limestones in Tasmania.
After BURRETT et al. (1984)

Key.

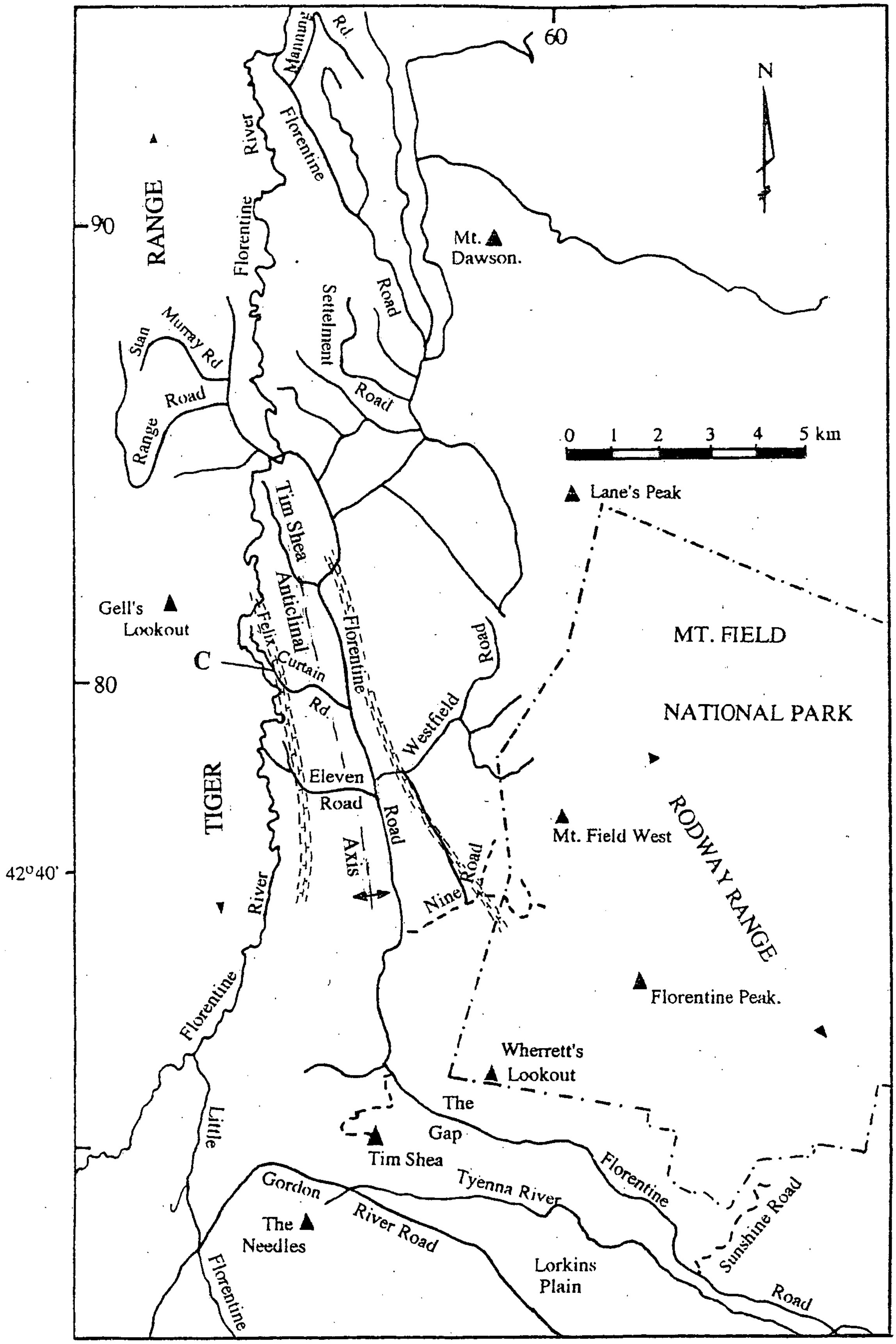
Cashions Creek Limestone.

Tim Shea Antinclinal Axis

Gravel roads

C Location site of conodont fauna.

Fig. 8.5. Locality diagram of the Cashions Creek Limestones cropping out on the Felix Curtain Road, in the Florentine Valley, Tasmania.
Section was thought to have been taken at C. The region is now impenetrable by vehicle due to vegetation regrowth.
The map has been compiled from CORBETT (1970), BURRETT (1978, unpub.), Land Services maps of Tasmania, and CANTRILL & BURRETT (2000).



60
N
90
80
42°40'
RANGE
TIGER
Manning Rd
Florentine River
Florentine
Settlement Road
Road
Mt. Dawson.
Stan Murray Rd
Range Road
0 1 2 3 4 5 km
Lane's Peak
Tim Shea Anticlinal Axis
Florentine Road
Gell's Lookout
C
Felix Curtain Rd
Westfield Road
MT. FIELD
NATIONAL PARK
Eleven Road
Nine Road
Mt. Field West
RODWAY RANGE
Florentine River
Florentine Peak.
Wherrett's Lookout
The Gap
Little Florentine
Tim Shea
Gordon River Road
Tyenna River
Florentine
Sunshine Road
The Needles
Lorkins Plain
Road

and from the Miaopo Formation (Darriwilian Stage) from South China (AN et al., 1985). The elements are closely related in age to the Tasmanian species.

"Scolopodus" nogamii LEE =*Panderodus nogamii* (LEE) (In: ALBANESI et al., 1995) has been recorded within the Darriwilian, Da3 Stage (*Eoplacognathodus foliaceus* to the *Eoplacognathodus robustus* Assemblage Zone). Elements of *"Parapanderodus" paracornutiformis* ETHINGTON & CLARK (=*Panderodus nogamii* LEE from Argentina ranged through the *B. laevis* to the *E. variabilis* Zone) (ALBANESI 1998b).

Panderodus nogamii (LEE) ranged from the Upper Arenig to the early Caradoc (*B. navis* to the lower *A. tvarensis* Zone) in Ordovician strata on Ko Tarutao and mainland Thailand.

Palaeobiogeography.

Where detailed sedimentological studies have been carried out in Tasmania (BURRETT et al., 1985, BURRETT et al., (1989, 1992), the Canning Basin (WATSON 1988), the Stokes Siltstone, Amadeus Basin ZHIANG et al., (2000), Malaysia (WONGWANICH (1990), Argentina (ALBANESI (1998b, LEHNERT & KELLER 1993), South China (AN et al., 1983, 1985, ZHENG et al:, 1983) it is evident that *Panderodus nogamii* lived in a high subtidal to lower intertidal environment on shallow carbonate platforms.

When plotted on an Middle Ordovician map based upon a palaeomagnetic reconstruction (Fig. 8.1) it is clear that *Panderodus nogamii* (LEE) was restricted to palaeolatitudes ranging from the equator in Tasmania to about 45°S in South China. Its absence from the higher palaeolatitudes of southern Europe could be due to an absence of carbonates of this age rather than a real absence of *P. nogamii* (LEE).

The distribution of *Panderodus nogamii* is similar to that of other Greater Gondwana fauna including the trilobite *Asaphopsoides* HUPÉ (Late Tremadoc to Arenig), and the gastropod *Peelerophon oehlerti* (BERGERON) of Arenig age (Fig. 8.1).

Summary.

A reconstruction of the continental masses forming the Ordovician Greater Gondwana from recent palaeomagnetic data indicates that only a few barriers, including distance, ocean current direction and water temperature would have impeded the migration Ordovician conodonts around the Greater Gondwana carbonate shelf regions.

Panderodus nogamii (LEE) successfully colonised most of the marine carbonate shelf environments around the perimeter of Greater Gondwana during the Early to Middle

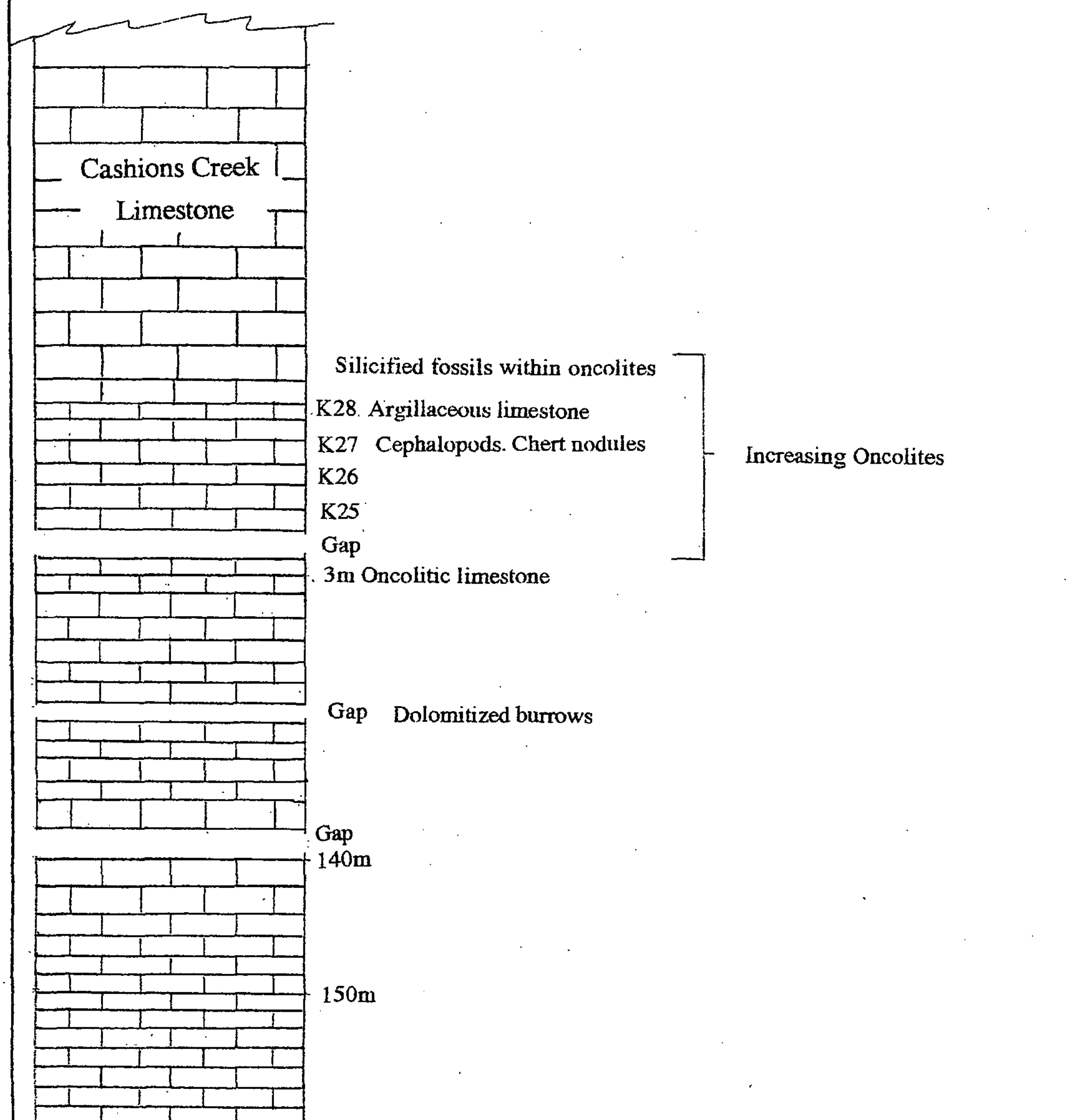


Fig. 8.6. Stratigraphic column of the limestone (Karmberg type) cropping out along the Felix Curtain Road, Florentine Valley Tasmania.

The area is not now accessible by vehicle due to forest regrowth. The stratigraphic column has been re constructed from the original field notes supplied by DR. CLIVE BURRETT.

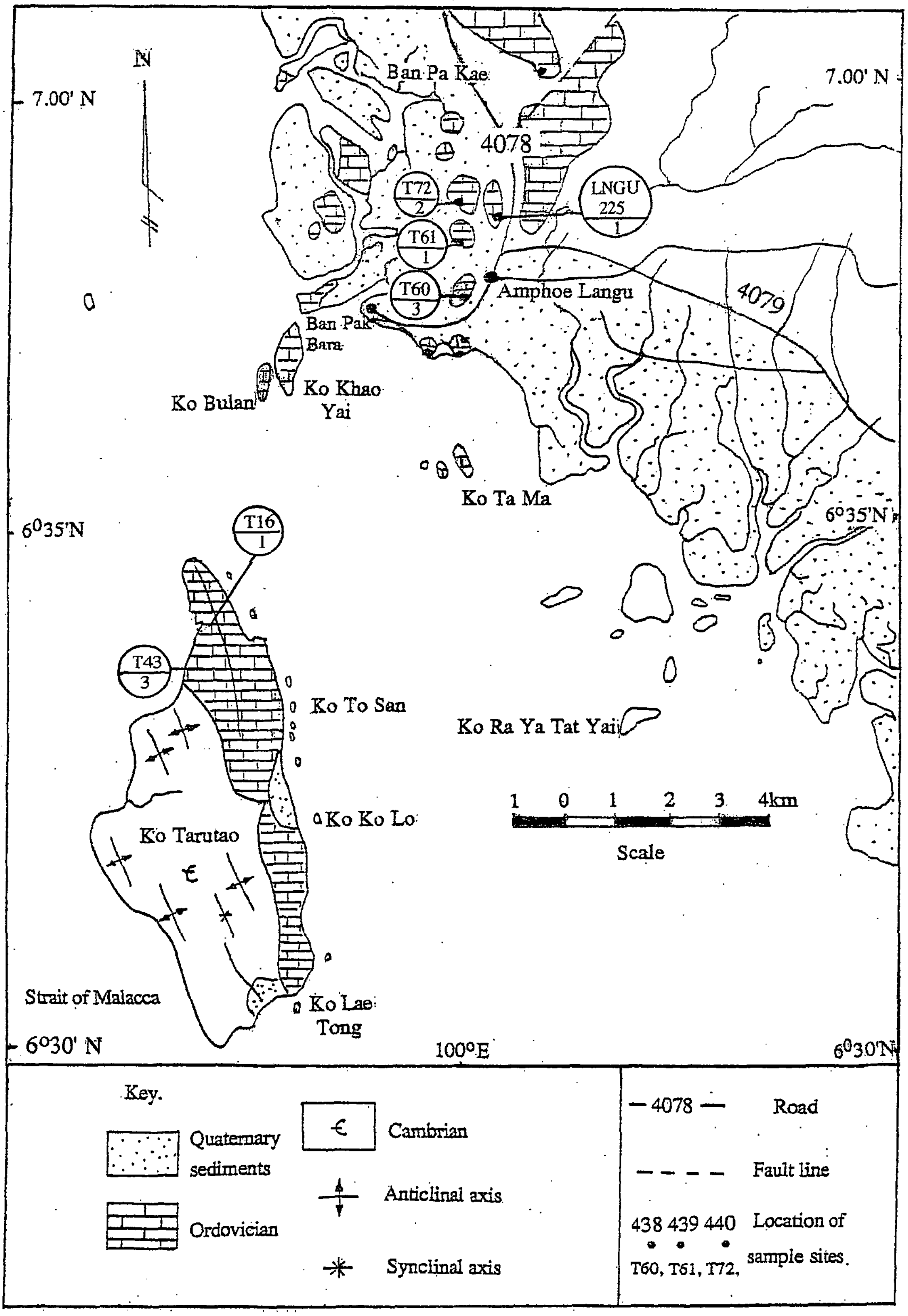


Fig. 8.7. Location sites of *Panderodus nogamii* (LEE) on Ko Tarutao and mainland Thailand.

After TANSUWAN et al., (1979), and WONGWANICH (1986). Additional information has been taken from the field note book of DR. C. BURRETT, University of Tasmania, Hobart.

Ordovician ranging from palaeolatitude 25°N to the cooler seas of South China at 45°S.

Table 8.1 is a correlation of some of the stratigraphical columns showing the age and the relative positions of specimens of *Panderodus nogamii* (LEE) within the stratigraphic columns discussed in this paper. The Table also indicates that some of the conspecific forms from Argentina are older than elements of *Panderodus nogamii* (LEE) from Australia, Tasmania, China, Thailand and Malaysia. It is possible that the form species of *Panderodus nogamii* (LEE) and the conspecific forms originated around the tropical limestones of the Middle Ordovician Precordillera of Argentina.

Taxonomic Comments.

The comments in this paper are restricted to elements that are identified as elements of *Panderodus nogamii* (LEE) or that are considered to be co–specific with the species *Panderodus nogamii* (LEE). The comparative ages of the species were determined by adapting and modifying the newly proposed Geological Time Scales of WEBBY et al., (1981) and COOPER (1999, p. 2).

Phylum: Chordata BATESON 1886
Class: Conodonta EICHENBERG 1930
sensu CLARK 1981

Genus *Panderodus* ETHINGTON 1959

Type Species: *Paltodus unicostatus* BRANSON & MEHL 1933a, p. 42.

Remarks:

NOWLAN & BARNES (1981) noted that the genus *Panderodus* ETHINGTON showed a broad diversity of coniform elements and apparatuses, which are difficult to rationalise.

JEPPSSON (1983b) suggested that there may be eight to ten homologous element types for some species of *Panderodus*. JEPPSSON (pers. com. 1999) suggested that large collections of a particular species are necessary to make an accurate identification down to at least the species level.

After studying JEPPSSON'S large collection of species of *Panderodus* housed at the Lund University, Gotland, Sweden SANSOM et al., (1994) suggested a new classification system for the different species of *Panderodus*. The authors have identified some six different element types for each species.

SWEET (1988) and ETHINGTON (pers. com. 1999) stated that the major diagnostic features of the genus *Panderodus* ETHINGTON is the distinctive longitudinal furrow on one or both sides of the cusp and the longitudinal striations on the sides of the cusp, especially around the basal region.

The basal cavity is rounded to sub rounded. The apex of the basal cavity reaches approximately half the length of the element and is inclined slightly towards the anterior edge.

Panderodus nogamii LEE 1975

Plates 8.1—8.5.

Type species: *Scolopodus nogamii* LEE 1975.

Synonymy:

1967 *Scolopodus* cf. *bassleri* (FURNISH); IGO & KOIKE, p. 234, Pl. 3, figs. 7–8.
1969 *Scolopodus* sp. nov. A. HILL et al., p. o.14–o.15, Pl. OVII, fig. 13.
1969 *Scolopodus* sp. nov. C. HILL et al., p. o.14–o.15, Pl. OVII, fig. 15.
1974 *Panderodus* sp. SERPAGLI; p. 59, Pl. 24, figs. 12–13, Pl. 30, figs. 12–13.
1975 *Panderodus striatus* (STAUFFER); LEE, p. 178, Pl. 1, fig. 14.
1975 *Scolopodus nogamii* LEE; p. 179, Pl. 2, Fig. 13, Abb. 3, L.
1981 *Protopanderodus primitus* (DRUCE); COOPER, p. 174–175, Pl. 27, figs. 3, 4.
1983 *Scolopodus nogamii* AN et al., p. 144, Pl. 13, fig. 20–25.
1986 *Protopanderodus primitus* (DRUCE); DZIK & DRYGANT, 138.
1988b *Panderodus* sp. SARMIENTO, et al., pp. 215–216, Pl. 1, fig. 1.
1988 *Parapanderodus "paracornutiformis"* (ETHINGTON & CLARK); STOUGE & BAGNOLI, p. 127, Pl. 7, figs. 6–9. (*cum syn.*)
1988 *Parapanderodus nogamii* (LEE); WATSON; pp. 124–125, Pl. 3, figs. 1a–b, figs. 6a, b.
1990 *Scolopodus nogamii* (LEE); AN & ZHENG, Pl. 2, figs. 15, 17; 20.
1993 "*Parapanderodus*" *nogamii* (LEE); LEHNERT, Pl. III, fig. 5.
1993 "*Parapanderodus*" *nogamii* (LEE); LEHNERT & KELLER, Pl. 1, figs. 4, 8.
1994 *Parapanderodus paracornuformis* (ETHINGTON & CLARK); POHLER, Pl. 7, fig. 6.
1995a "*Semiacontiodus*" *cornuformis* (SERGEEVA); LEHNERT, pp. 125–126, Pl. 7, fig. 22, Pl. 8, fig. 5, Pl. 9, figs. 14, 21, 22, Pl. 12, figs, 18, 19, figs. 21, 23, 24.
1995a *Parapanderodus nogamii* (LEE); LEHNERT, p. 106, Pl. 12, fig. 20.
1998b *Parapanderodus paracornuformis* (ETHINGTON & CLARK); ALBANESI, p. 116–117, Text–fig. 9, Pl. 12, figs. 8–13, (non–figs. 9, 10, 11).

Discussion:
The earliest descriptions of *Panderodus nogamii* (LEE) have been recorded as elements of *Scolopodus* cf. *bassleri* FURNISH (IGO & KOIKE 1967) from the Langkawi Islands, Malaysia. SERPAGLI (1974) described a *Panderodus* sp. from the San Juan Formation, Argentina and LEE (1975) reported a similar specimen as *Scolopodus nogamii* LEE from North Korea. Both specimens are assigned to *Panderodus nogamii* (LEE) herein.

Elements of the genus *Scolopodus* differ from elements of the genus *Panderodus* in several ways. Scolopodian elements are all hyaline elements and have a sharp costae, and a shallow basal cavity. ALBANESI (1998b) used the morphotype *Panderodus* sp. SERPAGLI and *Panderodus nogamii* (LEE) in his synonymy for *Parapanderodus paracornuformis* (ETHINGTON & CLARK). The elements illustrated in ALBANESI (1998b, p. 117, text–fig. 9: **e** , **a**. **c**, and **f**) are, in the authors' opinion, elements of *Panderodus nogamii* (LEE). They are not morphologically similar to elements of *"Semiacontiodus" paracornuformis* (SERGEEVA 1963) nor are they similar to *Parapanderodus paracornuformis* (ETHINGTON & CLARK).

The striated elements of *"Semiacontiodus" cornuformis* (SERGEEVA) described by LEHNERT (1995a, Pl. 7, fig. 22; Pl. 8, fig. 5; Pl. 9, figs. 14, 21, 22A and Pl. 12, fig. 18?) are also morphologically similar to elements of *Panderodus nogamii* (LEE). ETHINGTON (pers. com. 1999) considered that this species has been misinterpreted as the element has the typical panderodontid groove at the basal corner of the elements.

LEHNERT & KELLER (1993) and LEHNERT (1995a) also described elements of *"Parapanderodus" nogamii* (LEE) in which the base and the lateral sides of the cusp are striated in a similar way to *Panderodus nogamii* (LEE).

The shape of the cusp, the depth of the basal cavity, the longitudinal furrow along the mid line and faint basal striations are evident on the specimens illustrated as *Scolopodus* sp. nov. A, and *Scolopodus* sp. nov. C, (In: HILL et al., 1969, Plate OVII, figs. 13, 15) suggests that the elements from the Nora Formation, Toko Range, western Queensland, Australia are morphologically very similar to *Panderodus nogamii* (LEE).

Diagnosis:
Panderodus elements have a prominent costae, well developed striae and a basal cavity that reaches approximately half way up the cusp The cusp is slightly inclined towards the anterior margin. A notch is also prominent on the basal edge of the posterior side of the element (ROBISON 1981).

The faces on the posterior and the anterior surfaces of *Panderodus nogamii* (LEE) are broadly rounded and the faces have unequally developed carinae on the anterior sides. The base of the cusp has well developed deep striations, which do not cut the basal edge of the element. The shorter striations are often more deeply incised that the longer striations. Basal infilling has made it difficult to accurately determine the depth of the basal cavity for many elements.

A long, prominent furrow is evident along the mid line of the cusp on the Tasmanian specimens. The longitudinal furrow tapers as it nears the apex of the element and cuts the basal edge. The furrow varies in shape, from narrow to wide and from "V" to "U" shaped. Fine, longitudinal striae are also evident within the longitudinal furrow. Carinae are visible on the lateral faces of the elements. They do not extend along the full length of the cusp becoming inconspicuous on the lower third of the element at a point where they meet the shorter longitudinal striae.

Elements types of *Panderodus nogamii* (LEE) include:
M elements.
The elements are reclined to recurved and the characteristic longitudinal furrow and striations are evident. Some elements may have a small posterior basal projection. (Plate 8.1, fig. 1).

Sc elements.
The elements are proclined and more upright. The cusps are more longer and more slender.

Sb elements.
The elements are considered to be similar to M elements but are slightly more erect.

Sa elements.
The elements are reclined and the lower half of the element is stouter and more robust.

P elements.
Pb elements are robust, shorter with more upright cusps.
Pa elements are also robust elements but the cusps are have reclined cusps.

A model for an assemblage for *Panderodus nogamii* (LEE) is proposed in Plate 1 of this study. All elements show the main characteristics of *Panderodus nogamii* (LEE) mentioned above. The striations of the lateral faces of the elements of *Protopanderodus* sp. often tend to be inconspicuous. The element of *Protopanderodus primitus* DRUCE

(1981? (In: COOPER (1981, Pl. 27, fig. 4) from the Amadeus Basin in Central Australia is very similar to the Sb element of *Panderodus nogamii* (LEE) illustrated in this paper in Plate 8.1, figs. 9 and 10). The elements from the Amadeus Basin have longer, more slender cusps with a prominent lateral costae.

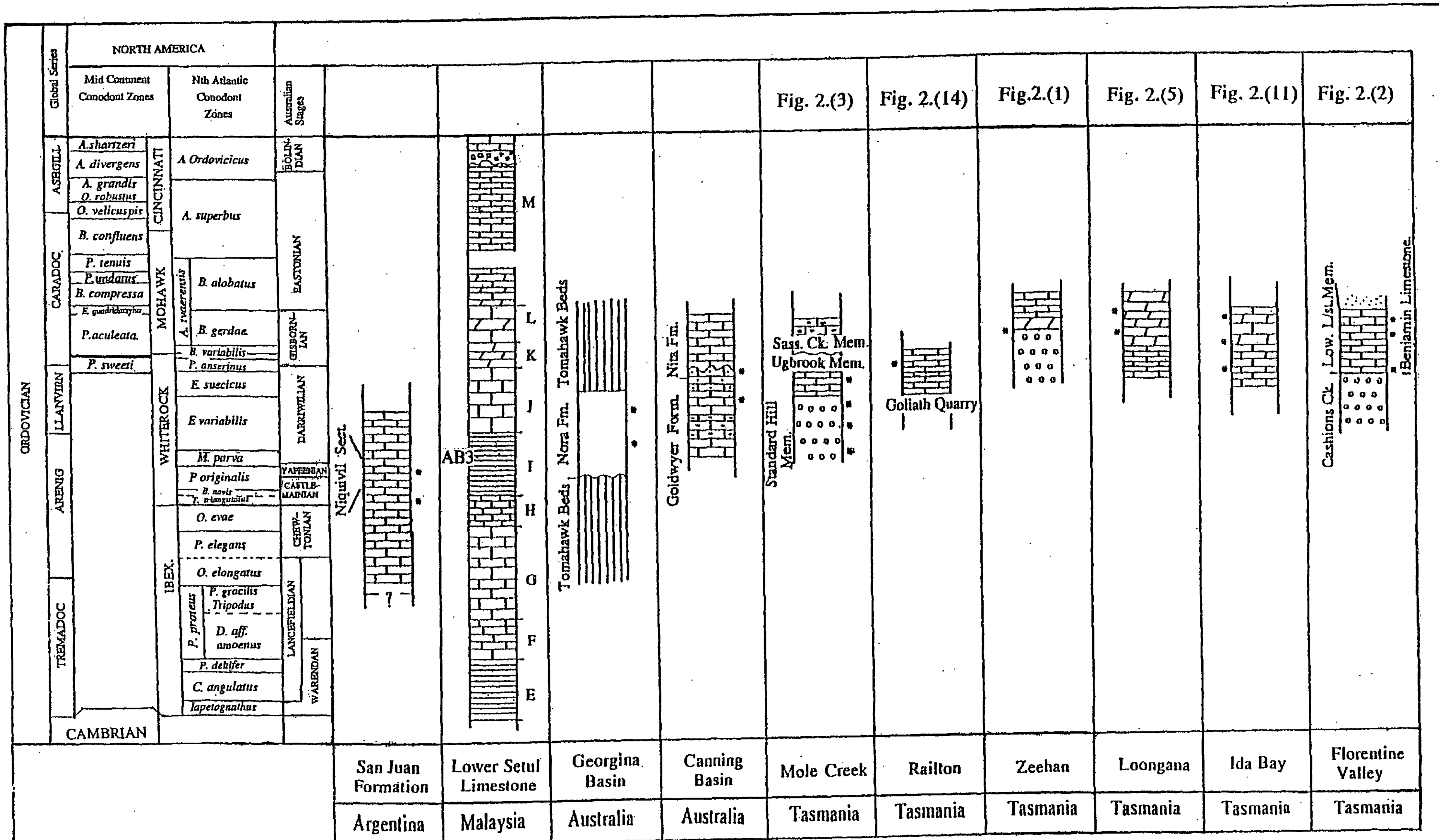


Table 8.1.

Table 1 has been compiled from data taken from the following sources. IGO & KOIKE (1967), BURRETT (1978, unpub.), WATSON (1988), SHERGOLD et al. (1991), LEHNERT (1995), WEBBY et al. (1981), COOPER (1999) and CANTRILL & BURRETT (in press).

Table 8.2.

The age and range of the conodont species *Panderodus nogamii* (LEE) 1975 from Tasmania, North Korea, South China, North China, Malaysia, Australia, and Argentina. After IGO & KIOKE (1967), BURRETT (1978,unpub.), AN et al., (1985), WATSON (1988), SHERGOLD et al., (1991), LEHNERT (1995a), WEBBY et al., (1981), COOPER (1999), CANTRILL & BURRETT (2000 in press), ZHANG & BARNES (2000, in press).

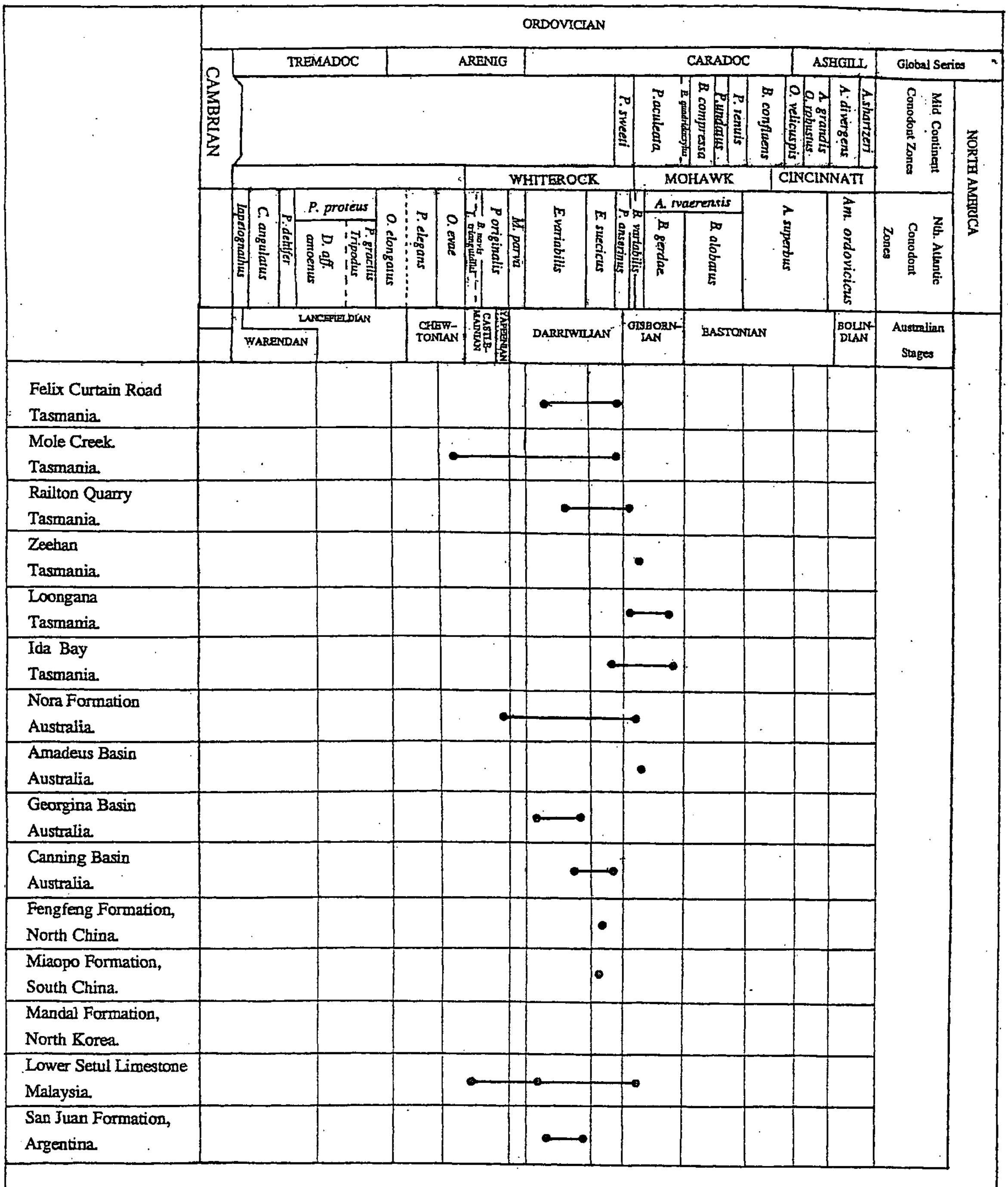


Plate 8.1.

The elements of *Panderodus nogamii* (LEE) from Tasmania are classified using the nomenclature in ROBISON (1981) and SWEET (1988). Additional information regarding the assemblage plan has been obtained from BARNES et al., (1979), SWEET (1988), JI & BARNES (1994a), ALBANESI (1998b, p. 106) and NICOLL (1995). All elements in Figs. 1–16 are from Loongana, Northern Tasmania unless indicated otherwise.

	M	Sc	Sb	Sa	Sd	Pb	Pa	
Anterior								**Posterior**
	e	a	b	d	c	f	g	

Anterior

M (e) element.	
1. Inner lateral view. X125	2. Outer lateral view of same element. X98.
Sc (a) elements.	
3. Inner lateral view. X95.	5. Outer lateral view of Fig. 4. X150.
4. Inner lateral view. X130.	6. Outer lateral view of Fig. 3. X140.
Sb (b) element.	
7. Inner lateral view. X110.	8. Outer lateral view of Fig. 7. X90.
Sa (d) element.	
9. Inner lateral view. X165	10. Outer lateral view of Fig. 9. X180.
Pb (f) elements.	
11. Inner lateral view. X170.	13. Outer lateral view of Fig. 11. X170.
12. Inner lateral view. X95.	14. Outer lateral view of Fig 12. X160.
Pa (g) elements.	
15. Inner lateral view. X85.	16. Outer lateral view of Fig. 15. X120.

Posterior


Plate 1
M
e
Anterior
1
2
Sc
a
3
4
5
6
Sb
b
7
8
Sa
d
9
10
Pb
f
11
12
13
14
Pa
g
Posterior
15
16

Plate 8.2.

Figs. 1–5. *Panderodus nogamii* (LEE).

Fig. 1. Inner posterolateral view of a P element from Loongana, Tasmania. TUGD128623

Fig. 2. Outer lateral view of a P element. The striae and the centrally placed lateral furrow are visible on the base of the eroded element. From Loongana, Tasmania. X300. TUGD128624

Fig. 3. Outer lateral view of an S element from Railton, Tasmania. X150. TUGD128625

Fig. 4. Inner lateral view of an M element from Loongana. X190. TUGD128626

Fig. 5. Inner lateral view of an M element from Ida Bay. X200. TUGD128627

Fig. 6. Magnified view of the base of the element in Fig. 5. TUGD128628

Fig. 7. Lateral view of an M element from Felix Curtain Road, Florentine Valley. TUGD128629

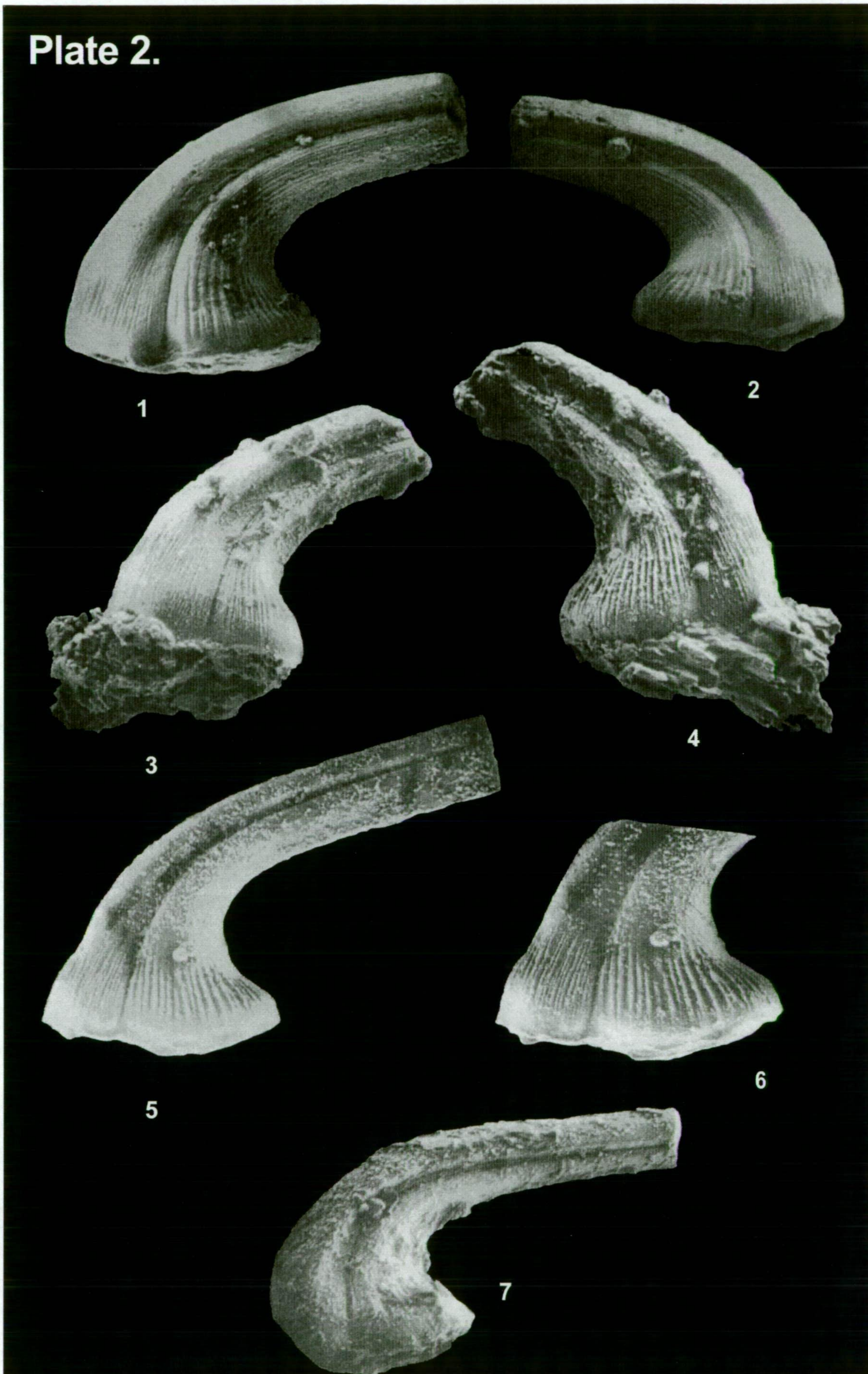


Plate 2.
1
2
3
4
5
6
7

Plate 8.3.

All of the elements *Panderodus nogamii* (LEE) reproduced in Plates 8.3 and 8.5 have been obtained from the Cashions Creek Limestone cropping out along the Felix Curtain Road, Florentine Valley, Tasmania.

Figs. 1–8. *Panderodus nogamii* (LEE).

Fig. 1. Lateral view of an Sa element. X170.	TUGD128630
Fig. 2. Lateral view of an M element. X215.	TUGD128631
Fig. 3. Lateral view of an Sa element. X180.	TUGD128632
Fig. 4. Lateral view of an Sc element. X300.	TUGD128633
Fig. 5. Lateral view of a Pb element. X145.	TUGD128634
Fig. 6. Lateral view of an Pa element. X190.	TUGD128635
Fig. 7. Lateral view of a Pa element. X225.	TUGD128636
Fig. 8. Anterio-posterior view of a Pa element. X150.	TUGD128637

Fig. 9. *Panderodus nogamii* (LEE). Longitudinal section viewed basally through the anterior side of the element. TUGD128638

The depth of the cavity is shown and its orientation towards the anterior side is shown. Damaged crystallites as well as pore openings are evident in the basal cavity. Pore openings in the basal filling are evident.

See BARNES et al., (1973, fig. 1B, p.14–15).


Plate 3.
1
2
3
4
5
6
7
8
9

Plate 8.4.

All specimens from the Felix Curtain Road site, Florentine Valley, Tasmania.

Figs. 1–7. *Panderodus nogamii* (LEE).

Fig. 1. Lateral view of an Sb element. X170.	TUGD128639
Fig. 2. Lateral view of an Sc element. X175.	TUGD128640
Fig. 3. Lateral view of an Sb-c element X165.	TUGD128641
Fig. 4. Lateral view of a Sb element. X170.	TUGD128642
Fig. 5. Lateral view of a Pb element. X210.	TUGD128643
Fig. 6. Lateral view of a Pb element. X160.	TUGD128644

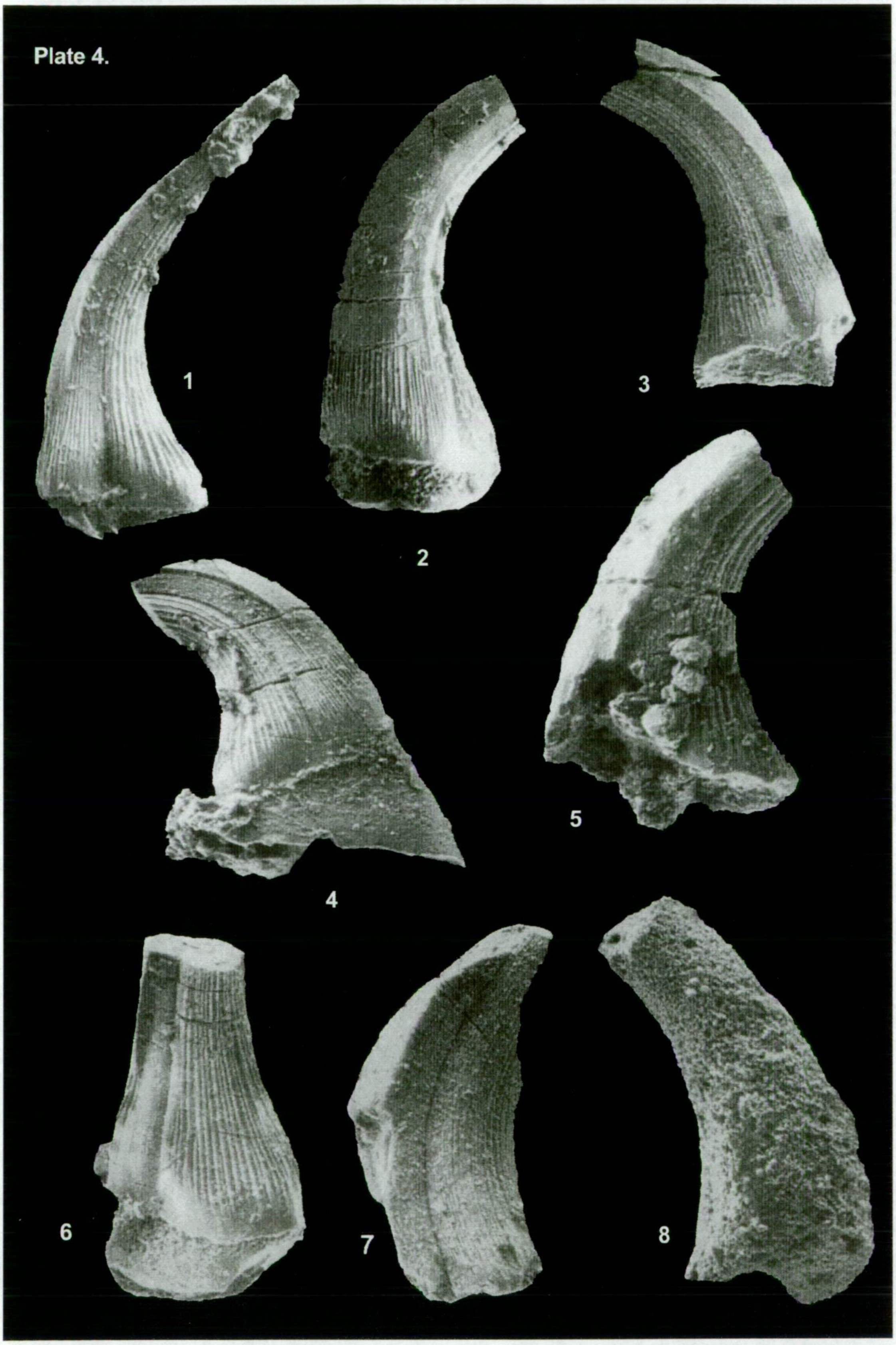
Fig. 7. *Panderodus* sp.

Posterolateral view of a damaged Pb? element. X165. TUGD128645

Fig. 8. Unassigned element. ?*P. nogamii* (LEE).

Fig. 8. Lateral view of recrystallised Sc? element. X200. TUGD128646

Plate 4.



Chapter 9

CAI values for Ordovician conodonts Malaysia, Thailand and Tasmania.

Introduction.

The variation in the colour of conodont elements was first documented by ELLISON (1944) and LINDSTRÖM (1964). EPSTEIN et al., (1974) used field results from the Appalachian Mountains to record the progressive and irreversible colour alteration of conodont elements.

Table 9.1. CAI values and conodont colour.

CAI	Colour
1	Yellowish white, china white, glossy.
1.5	Pale brown, translucent.
2	Brownish grey, greyish brown, waxy.
3	Pale grey, matt.
4	Darker grey, matt. Tips of denticles or cusps are white.
5	Black matt.
6	Grey.
7	Opaque white
8	Crystal clear, glassy.

From KOVÁCS & ÁRKAI (1987, p. 212).

EPSTEIN et al., (1977) showed that pressure alone did not influence the CAI values for conodonts. They concluded that water, in conjunction with confining pressure and heat, affected the carbon content of the conodonts up until at least CAI values of 5–6. KOVÁCS & ÁRKAI (1987) noted that in Alpine orogenic belts, fluids and stress pressures played an important role in the CAI values. The thermal boundaries for CAI values of 6–8 were established by REJEBIAN (et al., 1987).

CAI values can be used to compile a regional isograd maps showing thermal trends and anomalies in different regions (NOWLAN & BARNES, In: AUSTIN (1987, Ed.).

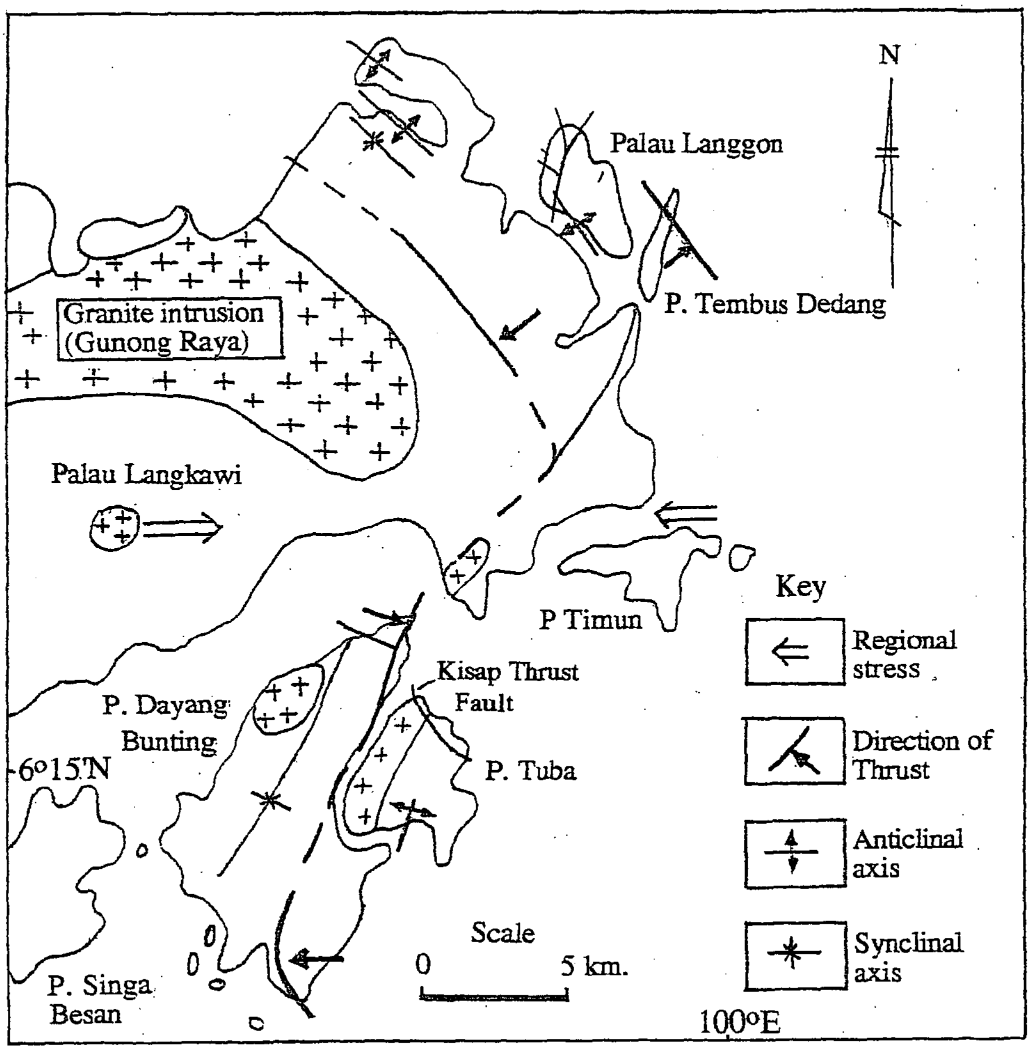


Fig. 9.1 Map of the Langkawi Islands showing the granite intrusion (Gunong Raya) and directions of regional stress. The directions of thrust along fault lines and the anticlinal and synclinal axes are also shown.
After JONES (1981).

CAI values for Ordovician conodonts Malaysia and Thailand.

Langkawi Islands, Malaysia.

Granite intrusions crop out on Palau Langkawi, P. Dayang Bunting, P. Tumin, P. Besar and P. Tuba (Fig. 9.1.). The granites may have intruded during the Late Carboniferous to Late Triassic (JONES 1981).

The Gunong Raya granite intrusion on the Langkawi Islands covers an area of some 100 square kilometres and forms the core of the main island. The intrusions may have influenced the folding and faulting of the sediments that formed on the eastern part of the group of islands. These sediments, containing conodont faunas, formed part of the eastward dipping limb of one of the north/south trending anticlines, the Machinchang anticline.

Table 9.2. The CAI values for conodonts from each section on P. Langkawi and P. Langgon.

Locations	Section	CAI Values	Colour	Formation
Palau Langkawi	GJO	2.0	Brown/grey	Lower Setul Limestone
Palau Langkawi	KD3	3.0	Pale grey matt	Lower Setul Limestone
Palau Langkawi	AE3	4.0	Darker grey	Lower Setul Limestone
Palau Langkàwi	KB12	4.0	Darker grey	Lower Setul Limestone
Palau Langkawi	AB7i	4.0	Darker grey	Lower Setul Limestone
Palau Langkawi	GJO	5.0	Black matt	Lower Setul Limestone
Palau Langgon	PLA 6	5.0	Black matt	Lower Setul Limestone
Palau Langgon	AB7	5.0	Black matt	Lower Setul Limestone
Palau Langkawi	KD3	5.0	Black matt	Lower Setul Limestone
Palau Langgon	M19	5.0	Black matt	Lower Setul Limestone
Unknown	LN11	5.0	Black matt	Lower Setul Limestone
Palau Langgon	AE3	5.0	Black matt	Lower Setul Limestone
Palau Langgon	TZ	5.0	Black matt	Lower Setul Limestone
Palau Langgon	BD17	5.0	Black matt	Lower Setul Limestone

KOOPMANS (1965), In: TJIA (1978) gathered evidence from suspected overfolding, thrust faulting and contact metamorphism associated with phyllites, metaquartzites, schists and slates within the Detrital Band in the Lower Setul Limestone. He interpreted fold directions as a result of older Middle to Late Devonian deformation and possibly as a result of an orogeny during the Triassic to Early Jurassic.

The isograd map in Fig. 9.2 shows the estimated CAI values for Ordovician conodont species from Palau Langgon, Palau Langkawi and the west coat of Thailand.

Conclusions: CAI values for the Langkawi Islands.

The variation in the CAI values for conodont specimens from the Langkawi Islands is dependent upon their proximity to faults, nappe folding (Fig. 9.1) and their contact with granitic intrusions. The granite intrusion (Late Carboniferous to Late Triassic) that formed the Gunong Raya intrusion on the main island other granitic stocks that have been exposed on P. Dayang Bunting, P. Tuba, P. Tumin and P Besar. (Figs. 9.1, 9.3).

The isothermal lines with a CAI value of 5.0 on Palau Langgon in Fig. 9.2**B** indicate a possible unexposed granite intrusion beneath the Ordovician sediments on that island. The CAI values may also have been affected by the movement of folding and faulting in that region.

CAI Values for conodonts from the Sections 438, 439, 440 Thung Song Group, Thailand.

The CAI values for conodonts from Sections 438, 439, 440, Thung Song Group (west coast of Thailand) ranged from 1.5 to 2.0

Table 9.3.

Section	CAI Value	Colour	Group
438	1.5	Honey coloured	Thung Song Group, Thailand.
439	2.0	Brown, grey	Thung Song Group, Thailand.
440	1.5	Honey coloured	Thung Song Group, Thailand.

The Thung Song Group, Ko Tarutao, Thailand and mainland Thailand.

A significant number of conodonts (270) have been obtained from geological sections taken on Ko Tarutao and mainland Thailand. The Sections producing conodont elements are listed in Tables 9.4, (and 9.5. below.

Except for Section T14 the CAI values on Ko Tarutao are influenced by the fault lines that cross the island in a north to south direction.

Fig. 9.2. A. Ko Tarutao and mainland Thailand.
B. Palau Langkawi, P. Langgon.

Maps show a plot of the isothermal lines derived from the CAI values obtained from conodont specimens examined from these sections.

Map details are taken from IGO & KOIKE (1967), TANSUWAN (1979), TERAOKA et al., (1982), WYATT (1983), WONGWANICH (1986), and WONGWANICH et al., (1990),

Key

Anticlines

Synclines

— — — Faults

—— 4.0 —— isothermal lines

—·—·—·— assumed direction of isothermal lines.

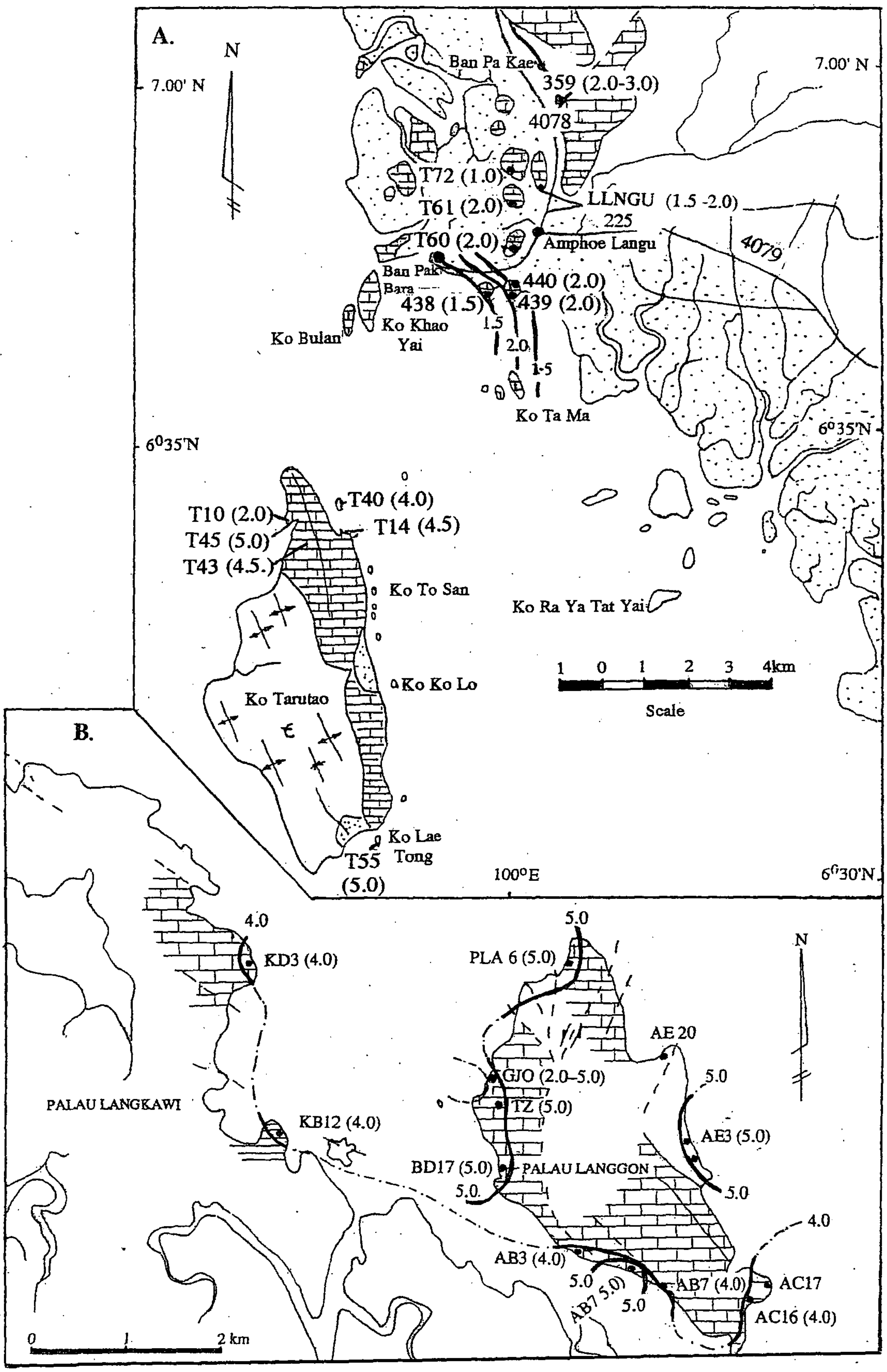
—— 4078 4079 Main roads.

438, 439, 440, 359, T60, T61, T72, T10, T45, T43, T40, T14, LLNGU 225, T55, KD3, KD12, PLA 6, GJO, BD17, AB3, AB7, AC16, AC17, AE3, AE2,	Conodont Sampling Sites.

Quaternary Sediments.

Ordovician.
Thung Song Group, Pa Kae Formation (Thailand).
Lower Setul Limestone, (Malaysia).

Late Cambrian to Lower Ordovician
(Tarutao Group, Thailand).



A.
N
7.00' N
Ban Pa Kae
359 (2.0-3.0)
4078
T72 (1.0)
T61 (2.0)
LLNGU (1.5 -2.0)
225
T60 (2.0)
Amphoe Langu
4079
Ban Pak Bara
440 (2.0)
438 (1.5)
439 (2.0)
Ko Bulan
Ko Khao Yai
Ko Ta Ma
6°35'N
T40 (4.0)
T10 (2.0)
T45 (5.0)
T14 (4.5)
T43 (4.5.)
Ko To San
Ko Ra Ya Tat Yai
Ko Ko Lo
1 0 1 2 3 4km
Scale
Ko Tarutao
Ko Lae Tong
T55 (5.0)
100°E
6°30'N
B.
KD3 (4.0)
PLA 6 (5.0)
AE 20
GJO (2.0–5.0)
TZ (5.0)
PALAU LANGKAWI
KB12 (4.0)
AE3 (5.0)
BD17 (5.0)
PALAU LANGGON
AB3 (4.0)
AB7 5.0)
AB7 (4.0)
AC17
AC16 (4.0)
0 1 2 km

Fig. 9.2. **A**. Ko Tarutao and mainland Thailand.
B. Palau Langkawi, P. Langgon.

Maps show a plot of the isothermal lines derived from the CAI values obtained from conodont specimens examined from these sections.

Map details are taken from IGO & KOIKE (1967), TANSUWAN et al.,(1979), TERAOKA et al., (1982), WYATT (1983), WONGWANICH (1986), and WONGWANICH et al., (1990).

Key — Anticlines — Synclines

Faults — 4.0 isothermal lines

assumed direction of isothermal lines.

4078 4079 Main roads.

438, 439, 440, 359, T60, T61, T72, T10, T45, T43, T40, T14, LLNGU 225, T55, KD3, KD12, PLA 6, GJO, BD17, AB3, AB7, AC16, AC17, AE3, AE2, — Conodont Sampling Sites.

Quaternary Sediments.

Ordovician.
Thung Song Group, Pa Kae Formation (Thailand).
Lower Setul Limestone, (Malaysia).

Late Cambrian to Lower Ordovician
(Tarutao Group, Thailand).

Table 9.4. Thung Song Group, Ko Tarutao, Thailand.

Section	Formation	Colour	CAI
T10	La Gna Formation	Pale brown	1.5–2.0
T14	Malaka Formation	Brownish–grey, waxy	2.0
T40	PaNam Formation	Dark Brown, grey	4.0
T43	PaNam Formation	Darker grey–black	4.5
T45	Malaka Formation	Black matt	5.0
T55	Rung Nok Form.	Black matt	5.0

The increase in values would be due to the faulting and folding that is evident on Ko Tarutao (See Fig. 9.2, A).

9.5. Thung Song Group, Thailand.

Section	Formation	Colour	CAI
T60	Thung Song Group	Brownish grey, waxy	2.0
T61	Thung Song Group	Black matt	5.0
T72	Thung Song Group	Very pale brown, crystalline	1.0
LLNGU 225	La Nga Formation	Pale brown	1.5–2.0

The CAI values for conodonts from mainland Thailand increase as they have been affected heat from the intrusion of bodies of granite during the Permian to Triassic (See Fig. 9.3).

CAI values for conodonts from Pa Kae Formation, Thailand.

WONGWANICH et al., (1990) defined the Pa Kae Formation (Caradoc) as the uppermost Formation of the Thung Song Group of Thailand cropping out in a very small area of Satun Province (Fig. 9.2, FORTEY 1997).

The CAI values of the conodonts from the section taken from the Pa Kae Formation show a slight increase in CAI values. These are tabled in Table 9.5 below. The CAI values of conodonts from Pa Kae have been affected by a fault cutting through the rock strata to the north of the Pa Kae Section (See Fig. 9.2) and a granite intrusion which has been exposed by erosion to the east of Pa Kae (Fig. 9.3).

Table 9. 6. CAI values for Ordovician conodonts from Pa Kae Formation, Thailand

Section	CAI Value	Colour	Formation
359	2.0–3.0	Brown, brown grey, to grey.	Pa Kae Formation.

CAI values for Ordovician conodonts from Tasmania.

Eaglehawk Gully Beaconsfield, Tasmania.

The CAI values of Tasmanian Ordovician conodonts has been reviewed by BURRETT (1978 unpub., and 1992).

Conodonts taken from the Eaglehawk Formation at Beaconsfield show a variation of CAI values from 4.0 to 5.0. These values could be affected by their proximity to the Badger Head Block to the north of Beaconsfield, the influenced of regional metamorphism as well as diagenetic movements. All conodonts specimens obtained from the Beaconsfield cores have been damaged.

The Gordon Limestone in the north and western Tasmania have CAI values that are influenced by their proximity to regions of maximum deformation such as the linear north to south fault lines and well as regional metamorphism. Conodont elements obtained the limestones from Railton, Loongana and Zeehan produced of CAI values of 5.0 (See Table 9.7).

The Karmberg Limestone, Florentine Valley.

Conodonts with the lowest CAI values of 1.5 to 2.0 were found just above the Florentine Valley Formation. Samples KARM1 to KARM 4 had a high clay content section and the limestone was less strongly folded or altered. Section KARM 10 contained conodonts with CAI values of 4.0. This indicates a steady increase in thermal activity upwards through this part of the limestone. Part of the increase in CAI values may be due to the nearly dolerite flows that occurred during the Jurassic.

Ida Bay, Southern Tasmania.

Ordovician conodont specimens from Ida Bay have a high CAI value. Samples from the Sections 2 and 176 have CAI values of 4.0. Conodonts from Section 58 had values ranging from 4.0 to 5.0. Dolerite sills may have had some effect of the CAI values in this region although an intrusion of dolerite occurred some distance away from this region.

Summary.

NOWLAN & BARNES (1987) have used the conodont CAI values for mineral exploration in Canada. CAI values of conodonts are now used routinely by the oil and gas industry to test for the maturation of potential sources for oil and gas (BAILLIE & BURRETT 1990).

Low CAI values 1.5 to 3.0 for Ordovician conodonts in southwest and central Tasmania suggest that the Gordon Group carbonates are present at depth and may be generating oil and gas in Tasmania (BURRETT1992).

Table 9.7. Variations in the observed CAI values for conodonts obtained from limestones of Ordovician age in Tasmania.

Location	Section	CAI Value	Colour
Southern Tasmania			
Ida Bay	176	4.0	Darker grey.
Ida Bay	2	4.0	Darker grey, white. tipped cusps
Ida Bay	58	4.0–5.0	Dark grey to black matt.
Northern Tasmania.			
Loongana		5.0	Black matt.
Railton		5.0	Black matt.
Zeehan	58	5.0	Black matt.
Mole Creek	55	5.0	Black matt.
Mole Creek	116	4.0	Dark Grey, white tipped cusps.
Bub's Hill		5.0	Black matt.
The Den	Den 2	4.0	Dark grey white tipped cisps.
Karmberg Limestone, Florentine Valley, Tasmania.			
	KARM 1	1.5	Pale brown
	KARM 4	2.0	Brownish grey
	KARM 6	3.0	Pale grey
	KARM 7	4.0	Darker grey
	KARM 8	3.0	Darker grey
	KARM 10	4.0	Darker grey
Flowery Gully Limestone and the Eaglehawk Formation, Beaconsfield, Northern Tasmania.			
	C8	4.0	Dark grey, white tipped cusps
	C18	4.0	" "
	C4	4.0	" "
	C16	4.0	" "
	C20	4.0	" "
	C31	5.0	Black matt.

Table 9.8. A summary of the Colour Alteration Indices values of Ordovician conodont specimens from the study areas. The colour of the conodont specimens are due to pressure/temperature regimes acting upon conodont specimens obtained from the Langkawi Islands, Malaysia, the Thung Song Group, the Pa Kae Formation Thailand, and Tasmania.

Key.

LI	Langkawi Islands, Malaysia.
TS	Thung Song Group, Thailand.
438, 439 440	Thung Song Group, Thailand.
359	Pa Formation Thailand
KARM	Karmberg Limestone, Tasmania
IB	Ida Bay, Tasmania.
MC	Mole Creek, Tasmania.
C4—C31	Beaconsfield, Tasmania.
+	Suggested CAI value. No sample number available.

C.A. I.	South east Asia.			Tasmania										
	Setul Limestone Malaysia	Thung Song L/stone Thailand	Pa Kae Fm. Thailand	Mole Creek Tasmania	Loongana Tasmania	Ida Bay Tasmania	Zeehan Tasmania	Railton Tasmania	Florentine Valley Tasmania	Felix Curtain Rd. Florentine Valley, Tas.	Beaconsfield Tasmania	Bub's Hill Tasmania	The Den Tasmania	Culver Tasmania
1. Yellowish white, china white, glossy Temp. <90°C		T72												
1.5 Pale brown, translucent Glassy	LI	438 440 LLNGU 225							KARM 1					
2 Brownish grey, greyish brown, waxy. Temp. 60-140°C	GJO	T10 T14 439 T60	PK 359						KARM 4					
3 Pale grey, matt Temp.110-200°C	KD3		PK 359	MC 135					KARM 6 KARM 8	+	C10 C14 C20 C11 C16		Den 2	+
4 Darker Grey, matt, tips of teeth white Temp.190-300°C	AB7 KB12 AB17 GJO	T40 T43		MC 55		IB 1 IB 2 IB 176	Zeehan 58	+	KARM 4	+				
5 Black matt Temp. 300-400°C	BD17 PLA6 AB7i KD3 M19 AE2 M19	T45 T55 T61		MC 55 MC116	+		ZEE 2			+	C31	BH 1		
6. Grey Temp.350-435°C	TZ1/2 LI													
7 Opaque white Temp.480-610°C														
8 Crystal Clear, Temp. 600°C+														

Chapter 10.

Summary and Conclusions.

> "Use the solution of each problem of a mode–of–life interpretation that best accords with the distribution facts."
>
> SWEET (1988, p. 152).

Introduction.
This thesis is a review of a collection of Ordovician conodont faunas from Southeast Asia and Tasmania.

Palaeoenvironmental indicators around Gondwana.
Biogeographic similarities between many fossil faunas from Australia, Tasmania, southeast Asia and South China suggests an Australian–Asian province existed around Gondwana during the Ordovician. Ordovician trilobite populations such as those within the *Asaphopsis* province are indicators of warmer, shallow, marine water around the margins of Gondwana (WHITINGTON & HUGHES 1972, 1973). The distribution of some fossil faunas around Gondwana are tabled in Tables 10.1 and 10.3

The correlation of conodonts with other fossils faunas helps to reconstruct the palaeobiology of a particular marine environment and the Early to Middle Ordovician faunal links between fauna Australia and the Sibumasu Terrane of and North and South China.

Ordovician Conodont Faunas.
Many very similar Lower to Upper Ordovician conodont genera and species have been recorded from Southeast Asia, Tasmania and Argentina, countries which one formed the ancient Gondwana continental land mass.

The conodont species listed in Table 10.2 indicate that there has been a mixing of conodont faunas from the warmer Midcontinent and the North Atlantic provinces in Australia Southeast Asia and South China. (LINDSTRÖM 1976, and COOPER 1981) noted a mixed fauna in the Canning Basin and the Amadeus Basin. STAIT & DRUCE (1993) noted that Ordovician conodonts from the Coolibah Formation have affinities with Ordovician conodonts from South China, North China and South Korea. A similar Upper

Region	Fauna	Rafinesquina imbrex	Rafesquina subdeltoidea	Spanodonta	Orthis	Aporthophyla	Aporthophyla tianjingshanensis ?	Strophomena sp.		Basiella satunensis	Teiichispera kobayashi,	Malayspira rugosa.	Malayspira sp.	Maclurites sp	Maclurites florentinensis
		Brachiopoda								Gastropoda					
	Australia														
Australia	Amadeus basin										•				
	Canning Basin,			•			•								
	Georgina Basin										•				
	Mr Arrowsmith NSW.														
	Toko Range. Cent. Aust.										•				
	Kimberley. West. Aust.			•							•				
	Tasmania										•			•	
India	India														
	Jacun Gp. Himalayas														
	Central Asia														
	Kazakhstan						•								
	MurmaShan States														
	Afghanistan														
Eastern Asia	Eastern Asia														
	Korea	•								•		•			
	China						•								
	Huanghanyuan														
	Liangchiashan L.North. China						•								
Burma	Thailand			•								•			
	Shihtein Facies														
	Naungkangyi Facies														
Thailand	Satun province	•					•			•	•	•			
	Tanjong Nalimhung Song														
	Kanchanaburi, Cent. Thailand.														
	Tha Manao Formation.														
	Huai Um Lu, Mai Ping.										•				
	Tanjong Malin, Bangkok.														
	Ko Turatao	•									•				
	Ko Si Chang														
	Ron Phibun														
Malaysia	Malaysia											•			
	Langkawi Islands			•			•				•	•	•		
	Palau Langgon			•			•				•	•			
	Palau Tembus Dendang										•				
	Palau Tangong														
	North America						•								
Argentina	Argentina														
											•				

Region	Fauna	Nautiloids	Actinoceras perlisense	Anthoceras	Orthoceras ?	Orthoceras sp.	Ormanoceras lankawiense	Ormanoceras sp. ident.	*Armenoceras chediforme	*Actinioceras chediforme	Actinoceras sp.	Hardmanoceras chrysanthimum,	Cf Discoceras (Hardmanoceras?) chrysanthimum	Hardmanoceras laeviventum	Cf Discoceras (Hardmanoceras?) laeviventum,	Manchuroceras sp.	Manchuroceras nakamense	Mesaktoceras
		Cephalopoda																
	Australia																	
Australia	Amadeus basin			•					•									
	Canning Basin,			•								•						
	Georgina Basin			•?					•						•	•		
	Mr Arrowsmith NSW.			•														
	Toko Range. Cent. Aust.																	
	Kimberley. West. Aust.																	
	Tasmania							•	•							•		
India	India																	
	Jacun Gp. Himalayas							•										
	Central Asia								•									
	Kazakhstan			•								•				•		
	MurmaShan States																	
	Afghanistan																	
Eastern Asia	Eastern Asia																	
	Korea														•	•	•	
	China							•								•		
	Huanghanyuan			•		•		•	•							•		•
	Liangchiashan L.North. China			•											•	•	•	
Burma	Thailand																	
	Shihtein Facies																	
	Naungkangyi Facies																	
Thailand	Satun province	•			•	•	•	•	•								•	
	Tanjong Nalimhung Song																	
	Kanchanaburi, Cent. Thailand.								•									
	Tha Manao Formation.								•									
	Huai Um Lu, Mai Ping.								•		•							
	Tanjong Malin, Bangkok.																	
	Ko Turatao	•							•			•	•		•	•	•	
	Ko Si Chang																	
	Ron Phibun																	
Malaysia	Malaysia																	
	Langkawi Islands								•		•	•	•		•		•	
	Palau Langgon	•?					•		•		•	•		•	•		•	
	Palau Tembus Dendang						•											
	Palau Tangong						•	•										
	North America								•									
Argentina	Argentina															•		

Region	Fauna	Georgina. linda	Wutinoceras robustum	Tofangoceras nanpiaoense	Sinoceras	Michelichoceras	Eosomichelinoceras	Calymene sp.	Asaphellus sp.	Hedinaspis	Pagodia	Harpides	Eosaukia	Saukia	Saukiella sp.	Cyclopyge	Proceratopyge
		Trilobites.															
	Australia																
Australia	Amadeus basin	•															
	Canning Basin,																
	Georgina Basin	•	•														
	Mr Arrowsmith NSW.																
	Toko Range. Cent. Aust.																
	Kimberley. West. Aust.																
	Tasmania		•														
India	India																
	Jacun Gp. Himalayas																
	Central Asia	•	•														
	Kazakhstan		•													•	
	MurmaShan States																
	Afghanistan															•	
Eastern Asia	Eastern Asia																
	Korea																
	China	•														•	
	Huanghanyuan	•															
	Liangchiashan L.North. China	•	•														
Burma	Thailand																
	Shihtein Facies																
	Naungkangyi Facies																
Thailand	Satun province		•													•	
	Tanjong Nalimhung Song																
	Kanchanaburi, Cent. Thailand.	•	•														
	Tha Manao Formation.																
	Huai Um Lu, Mai Ping.																
	Tanjong Malin, Bangkok.																
	Ko Turatao	•	•						•		•			•	•	•	
	Ko Si Chang																
	Ron Phibun																
Malaysia	Malaysia															•	
	Langkawi Islands	•													•		
	Palau Langgon	•	•														
	Palau Tembus Dendang																
	Palau Tangong																
	North America																
Argentina	Argentina		•														

Region	Fauna	Ovalocephalus ovatus	Xenocyclopyge	Nileus transversus	Nileus malayensis	Micropariamalayensis	*Sagavia	Microparia sagaviaformis	Rhemopleurella burmeisteri	Rhemopleurella inscupta	Rossaspis	Pseudokainella	Naushanaspis	Bulbaspis	Pseudokainella malakaensis	Telephina sp.	Telephina convexa.
		Trilobites.															
	Australia																
Australia	Amadeus basin																
	Canning Basin,																
	Georgina Basin																
	Mr Arrowsmith NSW.																
	Toko Range. Cent. Aust.																
	Kimberley. West. Aust.																
	Tasmania																
India	India																
	Jacun Gp. Himalayas																
	Central Asia																
	Kazakhstan						•										
	MurmaShan States					•											
	Afghanistan																
Eastern Asia	Eastern Asia																
	Korea																
	China		•														
	Huanghanyuan																
	Liangchiashan L.North. China																
Burma	Thailand																
	Shihtein Facies				•												
	Naungkangyi Facies																
Thailand	Satun province	•		•	•				•	•							
	Tanjong Nalimhung Song																
	Kanchanaburi, Cent. Thailand.																
	Tha Manao Formation.																
	Huai Um Lu, Mai Ping.																
	Tanjong Malin, Bangkok.																
	Ko Turatao								•	•	•	•			•		
	Ko Si Chang																
	Ron Phibun																
Malaysia	Malaysia			•													
	Langkawi Islands																
	Palau Langgon																
	Palau Tembus Dendang																
	Palau Tangong																
	North America																
Argentina	Argentina																

Region	Fauna	Stromatoporoids	Labechia variabilis Yabe & Sugiyama 1930	Rosenella woyuensis Ozaki 1938	Miscellaneous	Liospira rectangularis	Basiella satunensis	Mazuelloids	Polyplacophoran	Chelodes whitehousei	Peelerophon oehlerti Bergeron
	Australia										
Australia	Amadeus basin										
	Canning Basin,									•	•
	Georgina Basin										
	Mr Arrowsmith NSW.										
	Toko Range. Cent. Aust.										
	Kimberley. West. Aust.										
	Tasmania							•			•
India	India										
	Jacun Gp. Himalayas										
	Central Asia										
	Kazakhstan										
	MurmaShan States										
	Afghanistan										
Eastern Asia	Eastern Asia										
	Korea										
	China										
	Huanghanyuan										
	Liangchiashan L.North. China										
Burma	Thailand										
	Shihtein Facies										
	Naungkangyi Facies										
Thailand	Satun province									•	
	Tanjong Nalimhung Song										
	Kanchanaburi, Cent. Thailand.										
	Tha Manao Formation.										
	Huai Um Lu, Mai Ping.										
	Tanjong Malin, Bangkok.										
	Ko Turatao									•	•
	Ko Si Chang										
	Ron Phibun										
Malaysia	Malaysia										
	Langkawi Islands										
	Palau Langgon										
	Palau Tembus Dendang										
	Palau Tangong										
	North America										
Argentina	Argentina										
										•	•

Table 10.1. The distribution of selected Ordovician fossil fauna around countries forming Gondwana including Argentina, India, Australia, and southeast Asia.

Ordovician conodont affinity is discussed a mixed conodont fauna from the Malongulli Formation of central N.S.W. (TROTTER & WEBBY 1994,) and from the Hensleigh Siltstone of NSW (ZHEN et al., 2001).

Correlation of Conodont faunas.

The North America Midcontinent Province (warm water), and the North Atlantic Province (cool water) as well as European Provinces such as the Baltoscandia and the Siberian regions have been documented. Bathymetric and water temperatures appear to have the most dominant palaeoenvironmental effect on conodont distribution around Gondwana (SWEET & BERGSTRÖM 1984, MILLER 1984). Many of the conodont species recorded have been recorded from the North Atlantic realms of Laurentia including eastern Canada and Europe are tabled in Table 10.1.

Australia.

By the Late Ordovician the distribution of nautiloids species was affected more directly by tectonic settings and ocean depths that served to isolate the Tasmanian shallow water platform faunas (WEBBY et al., 2000). Tasmanian conodont genera include *Eoplacognathus, Pygodus* and *Oepikodus evae Phragmodus, Oulodus, Belodina, Plectodina* are typical of conodonts which inhabit shallow water carbonate associated with a North Atlantic Province fauna (NICOLL, In: WEBBY & NICOLL 1991).

The Karmberg Limestone produced 31 different genera. The conodont species which have a wide distribution include *Bergstroemognathus extensus, B. kirki, Cornuodus longibasis, Drepanodus arcuatus, Juanognathus variabilis, Jumudontus gananda, Paracordylodus gracilis, Protopanderodus gradatus,* and *Reutterodus andinus.* Many of these species have been recorded within the Lower Ordovician (Bendigonian) conodont fauna from the shelf edge deposits forming the Hensleigh Siltstone in N.S.W. (PERCIVAL et al., 1999 and ZHEN et al., 2001). Many of these conodont species are common to Argentina (SERPAGLI 1974, LEHNERT 1995, ALBANESI 1998b), and South China (AN et al (1984) and WANG et al., (1996),

Table 10.2. (Over). Information compiled from SERPAGLI (1974), ETHINGTON (1978), AN et al., (1985), STOUGE (1984), STAIT & DRUCE (1993), WRIGHT et al., (1994), POHLER (1994), ZHEN & WEBBY (1995), TROTTER & WEBBY (1994), LEHNERT (1995a), WANG et al., (1995), JI & BARNES (1996), ALBANESI (1998b), FERRETTI & SERPAGLI (1999), LEHNERT et al., (1999), LÖFGREN et al., (1999), WEBBY et al., (2000), In: WRIGHT et al., Eds: 2000) and RASMUSSEN (2001).

Conodont species / Location	Langkawi Is. Malaysia Lower Setul Limestone	Ko Tarutao, Thailand Thung Song Group.	Thailand Thung Song Group	Thailand Pa Kae Formation	Yangtze Province South China	Argentina San Juan Formation	Beaconsfield, Tasmania Flowery Gully Fm.	Tasmania Karmberg Limestone	Australia Amadaeus Basin	Australia Canning Basin	Australia Cliefden Caves NSW.	Australia Georgina Basin	NSW Australia Hensleigh Siltstone	New Zealand Mt. Patriarch	Canada Survey Peak Form.	Newfoundland Table Head Formation	Canada Cows Head Conglom.	USA El Paso Formation	USA Utah, Ibex	Europe Baltoscandia	Scandinavian Caledonides Scandinavia
Acodus combsi							+														
Acodus deltatus deltatus		+								+				+			+	+	+		+
Acodus oneotensis	+					+												+			
Acodus similaris			+															+			
Acontiodus iowensis		+			+		+	+						+			+	+			
A. cf. propinquus																		+			
Aurilobodus ? leptosomatus								+					+								
Amorphognathodus ordovicicus				+		+														+	
Amorphognathodus tvaerensis		+				+														+	
Ansella jemtlandica	+	+				+															+
Baltoniodus navis				+	+	+															+
Belodella jemtlandica			+													+					
Bergstroemognathus extensus		+				+							+				+				
Bergstroemognathus kirki		+										+									
Besellodus sp.			+								+										
Cordylodus caseyi		+					+								+						
Cordylodus lindstromi	+	+												+	+			+			
Cordylodus proavus						+									+		+				
Cordylodus ramosus		+												+							
Cornuodus longbasis	+		+	+	+			+					+			+	+			+	+
Dapsilodus mutatus	+		+	+	+	+		+			+									+	
Drep, arcuatus		+			+	+	+	+					+				+	+	+		+
Drepanoistodus basiovalis	+	+	+	+	+	+		+		+						+	+				+
D. erectus						+							+				+				
D. forceps.	+	+			+			+			+					+	+		+		+
D. concavus		+																+			
D. inaequalis	+																+				
D. pervetus		+					+								+						
D. suberectus						+	+		+	+	+			+				+			+
D. toomeyi	+													+				+		+	+
Erismodus gracilis							+	+													
Erraticodon sp.		+				+											+				
Eoplacognathus elongatus			+			+															
Glyptoconus quadriplicatus						+											+				
Hamarodus europaeus	+		+	+	+															+	
Juanognathus jaanussoni		+			+	+		+										+			
Juanognathus serpaglii		+														+					
Juanognathus variabilis	+	+	+	+	+	+	+	+					+	+			+	+	+		
Jumudontus ? gananda	+					+		+					+				+				
Loxodus bransoni		+															+	+			

Table 10.2. The distribution of Ordovician conodont species in Australia, North America and Europe.

Conodont species / Location	Langkawi Is. Malaysia Lower Setul Limestone	Ko Tarutao, Thailand Thung Song Group.	Thailand Thung Song Group	Thailand Pa Kae Formation	Yangtze Province South China	Argentina San Juan Formation	Beaconsfield, Tasmania Flowery Gully Fm.	Tasmania Karnberg Limestone	Australia Amadaeus Basin	Australia Canning Basin	Australia Cliefden Caves NSW	Australia Georgina Basin	NSW Australia Hensleigh Siltstone	New Zealand Mt. Patriarch	Canada Survey Peak Form.	Newfoundland Table Head Formation	Canada Cows Head Conglom.	USA El Paso Formation	USA Utah, Ibex	Europe Baltoscandia	Scandinavian Caledonides Scandinavia
Microzarkodina ?flabellum	+	+			+	+				+									+		+
Oepikodus evae	+	+			+	+		+									+				+
Oistodus lanceolatus	+				+	+		+						+			+	+			+
Oistodus sp.		+											+								
Oneotodus nakamuri		+						+									+				
Panderodus gracilis	+	+	+		+	+			+	+	+								+	+	
Panderodus nogamii		+				+			+												
Panderodus panderi			+							+	+										
Paracordylodus gracilis		+				+							+								+
Parapaltodus simplicissmus	+	+				+										+	+				
Parpanderodus numarcuatus			+			/											+				
P. originalis										+							+				
Periodon flabellum					+	+				+											
Phragmodus flexuosus		+				+			+	+									+		
Ph. tasmaniensis																					
Phragmodus undatus		+	+			+				+	+										
Polonodus sp.						+		+													+
Protopanderodus elongatus		+				+		+									+				
Protopanderodus gradatus		+			+	+		+					+				+	+	+		
P. insculptus				+	+		+				+										
P. liripipus	+	+		+	+						+					+					
P. rectus					+	+		+		+							+				+
P. varicostatus			+		+	+	+	+		+				+		+	+				
Pteracontiodus cryptodens								+											+		
Reutterodus andinus						+		+					+	+				+	+		
Rossodus manitouensis						+		+							+		+			+	
Scabardella altipes											+									+	
Scandodus furnishi						+		+										+	+		+
Scalpellodus sp.		+	+					+									+				
Scolopodus filosus								+				+		+			+	+			
Scolopodus floweri						+		+										+			
Scolopodus gracilis		+					+											+			
Scolopodus giganteus																					
Scolopodus krummi		+						+													
Scolopodus rex	+	+			+	+	+	+		+					+			+	+		
Scolopodus staufferi		+																			
"Semiacontiodus" cornuformis		+				+		+													+
Tasmanognathodus sp.								+			+										
Teridontus nakamuri						+									+		+				
Triangulodus variabilis	+	+			+																
Variabiloconus variabilis								+				+								+	
Walliserodus ethingtoni	+		+	+	+	+										+	+				
Zanclodus levigatus			+								+										

Table 10. 2. The distribution of Ordovician conodont species in Australia, North America and Europe.

Bergstroemognathus kirki is endemic to central and northern Australia (STAIT & DRUCE 1993) and indicates a shallow warm water environment. Both *Phragmodus* species and *Bergstroemognathus extensus* indicate changes in water depths from littoral (shallow) to deeper water. (ZHEN et al, 2001).

The conodont fauna from Beaconsfield, Northern Tasmania.

The Eaglehawk Gully Formation is a typical estuarine, tidal flat deposit. The offshore carbonate shoals developed along the shore line and deepened towards the west of Beaconsfield. Deeper water is indicated by the presence of bioclastic wackestones at the top of the formation.

?*Dalmanitina* sp. (Bolindian age) from slates from the Flowery Gully Formation, Beaconsfield, Tasmania indicated that a cool water "*Hirnantia* fauna" was widely distributed around Gondwana in different latitudinal zones (COCKS & FORTEY 1988, WEBBY et al., 2000, p. 86).

The small number of conodonts from Beaconsfield (thirty specimens) is too few to draw any comparisons with other Lower Ordovician fauna from Tasmania. KENNEDY (1971, unpub.) reported some thirty species of the genus *Oistodus*, that are the most common conodont species from Beaconsfield. Many of these are possibly be M elements of other species.

Southeast Asia.

Langkawi Islands, Malaysia.

Much of the work concerning the study of Ordovician fossils faunas was pioneered by JONES (1968, 1981), KOBAYASHI (1959, 1966, 1984), IGO & KOIKE (1967) and KOBAYASHI & HAMADA (1964, 1967 1978). Later studies were done by BURRETT & STAIT (1985, 1987) BURRETT et al., (1984. 1990, LAURIE & BURRETT (1992).

Chapter 3 outlines the synonymy and distribution of the Lower to Middle Ordovician conodont fauna recovered from the Langkawi Islands of Malaysia eighteen genera and thirty eight species were discussed from the Langkawi Islands.

Depositional environment, Langkawi Islands.

The Lower Setul Limestone is a thick deposit of hard dark limestone which is typical of a shelf limestone deposit. There is a strong correlation between the Lower to Middle Ordovician conodont fauna from the Langkawi Islands and the Thung Song Group of Thailand.

The Langkawi Islands conodont fauna ranges from the Lower Ordovician through to at least the Mid Ordovician in the Setul Limestone. Some of the conodont species are pandemic and are found around the countries forming Gondwana during the Ordovician and in both the North American and North Atlantic Midcontinent faunas. (IGO & KOIKE 1967, SWEET & BERGSTRÖM 1984). (Table 10.2).

Thung Song Group, Thailand.

Depositional Environment.

The Thung Song Group was deposited . . . . "as a homoclinal ramp carbonate complex with marine shelf and lagoonal deposits. WONGWANICH (1990, unpub.). The Thung Song Group is composed of Ordovician tropical carbonates and minor shales. The sequences and the types of lithological units through the Thung Song Formation on Ko Tarutao has been documented in Chapter three. The Ordovician conodont fauna from the Thung Song Group and Pa Kae Formation of Thailand become progressively younger across the geological strata which deepen in an north easterly direction from Palau Langgon to the Pa Kae Formation near Ban Pa Kae, Thailand.

Conodont fauna from the Thung Song Group, Thailand, Ko Tarutao and mainland Thailand.

Approximately 400 conodonts were obtained from the Thung Song Group on Ko Tarutao and mainland Thailand. Many similar conodont species including *Bergstroemognathus extensus, Drepanodus arcuatus, Juanognathus variabilis, Oepikodus evae, Phragmodus flexuosus, Phragmodus undatus, Protopanderodus* sp. Thung Song indicate the *P. elegans* (Chewtonian) and the *O. evae* Zone (Castlemainian). These species have been recovered from the Karmberg Formation of Tasmania and the Hensleigh Formation in N.S.W.

Several of the Thung Song conodont fauna including *Drepanoistodus suberectus, Panderodus gracilis* and *Phragmodus undatus* shows are also common to the Ordovician North American Midcontinent conodont faunas from Argentina, south east Asia, South China and the El Paso Formation, U.S.A.(Table 10.2.).

Conodonts from the Pa Kae Formation, Thailand.

A small sample of 13 genera were obtained from the Pa Kae Formation. (Upper Ordovician (*Pygodus serrus* Zone to *A. tvarensis* Zone).

Palaeobiostratigraphy of the Lower Ordovician conodonts of Tasmania.

BARNES & FÅRHÆUS (1974) noted that a pelagic conodont fauna including *Drepanodus, Drepanoistodus, Paroistodus* and *Paltodus* dominate the Arenig fauna.

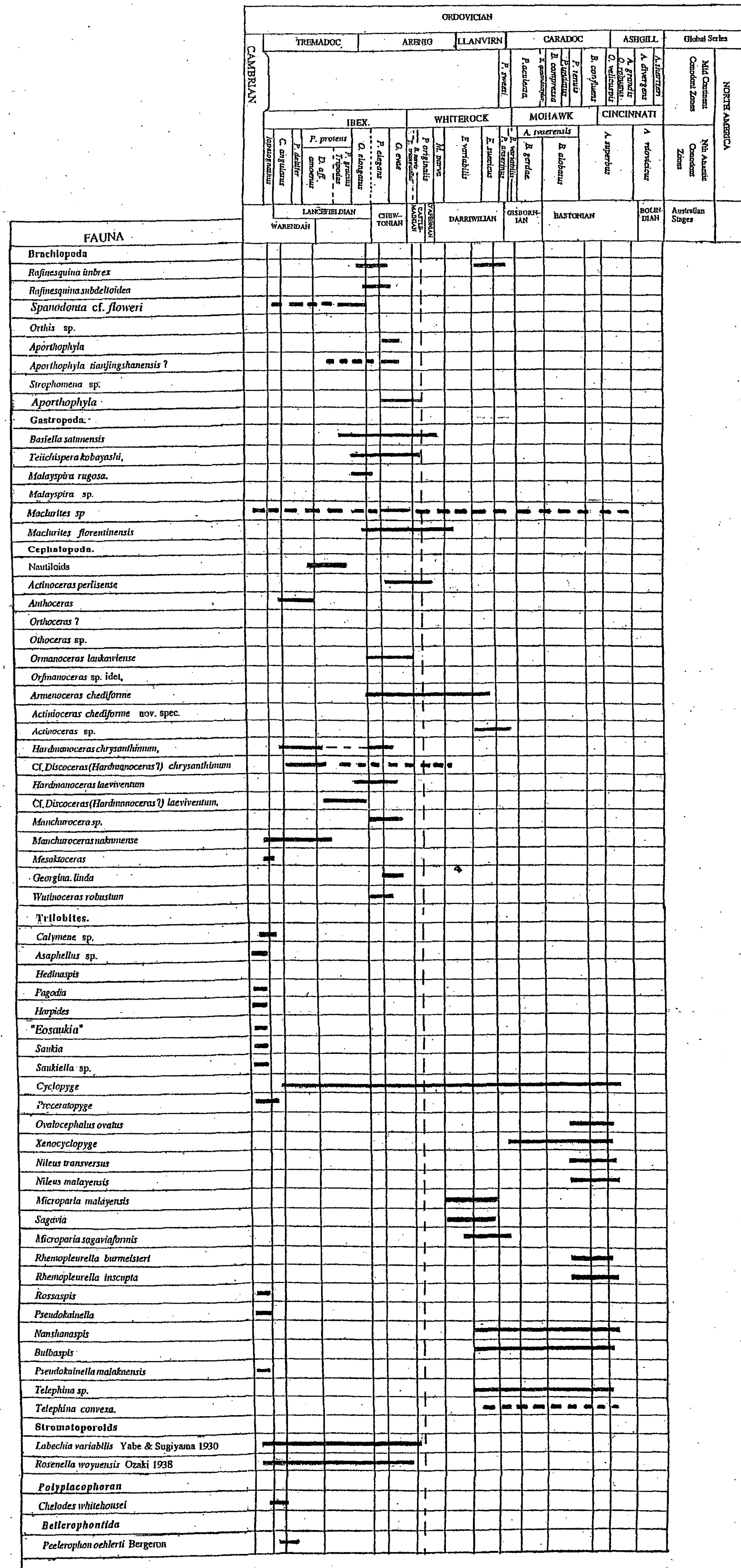


Table 10.3. Age range of selected Ordovician brachiopod, gastropod, cephalopod, stromatoporoid fauna recorded from southeast Asia and Australia.

The conodonts recovered from the different regions of Tasmania are coeval with other well known cosmopolitan species. The Ordovician conodont fauna of Tasmania are mostly found in sediments that have been deposited in shallow marine conditions associated with carbonate platforms.

Carbonate turbidites found in southern Tasmania investigated by BURRETT et al., (1983) and BURRETT et al., (1984) containing *Periodon aculeatus, Protopanderodus varicostatus, Eoplacognathus elongatus, Amorphognathus tvaerensis* and *Protopanderodus liripipus* are typical of North American Province type conodont fauna. These species typically occur along platform margins.

The sedimentary environment at southern Tasmania (Middle to Upper Ordovician) shows a transition from peritidal carbonate at Ida Bay (*Phragmodus* sp. indicates a warmer water region SWEET 1979) to deep subtidal carbonates at Point Cecil some 25 km away. The deeper water facies often contain a cosmopolitan conodont population including *Protopanderodus varicostatus, P. liripipus,* and *Eoplacognathus* in the lowest turbidites. The conodonts show affinities with conodont faunas from Southern China (AN et al., 1985) and North Atlantic province conodonts (BURRETT et al., 1984).

Drepanoistodus suberectus, Panderodus gracilis tended to inhabit all types of environments. *Dapsilodus mutatus* and *Protopanderodus liripipus* have been identified as conodont species that inhabit stenothermal conditions and inhabit the colder, deeper waters in the lower latitudes realms in both the Northern and Southern hemispheres during the Ordovician (TROTTER & WEBBY 1994). The conodont species indicate that this type of environment extended over the limestones forming within Central N.S.W. up to at least the Upper Ordovician.

The shallow, warm water communities include *Belodina* sp., *Zanclodus levigatus* and *Besselodus* sp. which are often found in association with North American Midcontinent species.

Palaeoecology.

North Atlantic conodont species include *Dapsilodus mutatus* BRANSON & MEHL, *Protopanderodus insculptus* BRANSON & MEHL, *Protopanderodus liripipus* KENNEDY et al., and *Scabardella altipes.* All species have been collected from Tasmanian Ordovician limestone at Beaconsfield and Karmberg Limestone.

The North American Midcontinent conodont faunas includes *Panderodus gracilis* BRANSON & MEHL, *Paroistodus* sp., *Phragmodus undatus* BRANSON & MEHL and

Panderodus panderi. *Drepanoistodus suberectus* BRANSON & MEHL is found in both faunal provinces in the North American and North Atlantic provinces (SWEET & BERGSTRÖM 1984). The species is typical of cold water depositional environments.

A Late Ordovician conodont faunas has a wide distribution from the Forks Lagoon Beds of Queensland, PALMIERI (1978), to central N.S.W. (TROTTER & WEBBY, 1995, ZHEN & WEBBY 1995, PERCIVAL 1999, PERCIVAL et al., 1999) through to Tasmania (this study).

Chapter 11.

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Chapter 12.

APPENDIX.

The separation of conodont specimens from acid residues.

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Chapter 12.

The separation of conodont specimens from acid residues.

12.1. Introduction.

The extraction of conodonts by the use of heavy liquids such as sodium polytungstate has been documented by JEPPSSON (1987), STONE (1987), MERRILL (1987), SAVAGE (1988), MAWSON (1988), MORROW & WEBSTER (1989) and JEPPSSON (1999, pers. com.) The steps involved in the extraction of conodonts from acid residues are similar to the steps suggested in ANDERSON et al., (1995). The process and steps outlined in this paper are documented from experience and advice received from other sources. The process is outlined in some detail to offer some guidance to palaeontologists who may not have had experience in the extraction of conodonts from acid residues.

12.2. The Acid Leaching Process to obtain conodont specimens from limestones.

The acid leaching process has been found to be one of the most successful laboratory processes in obtaining conodonts from residue material from limestone samples.

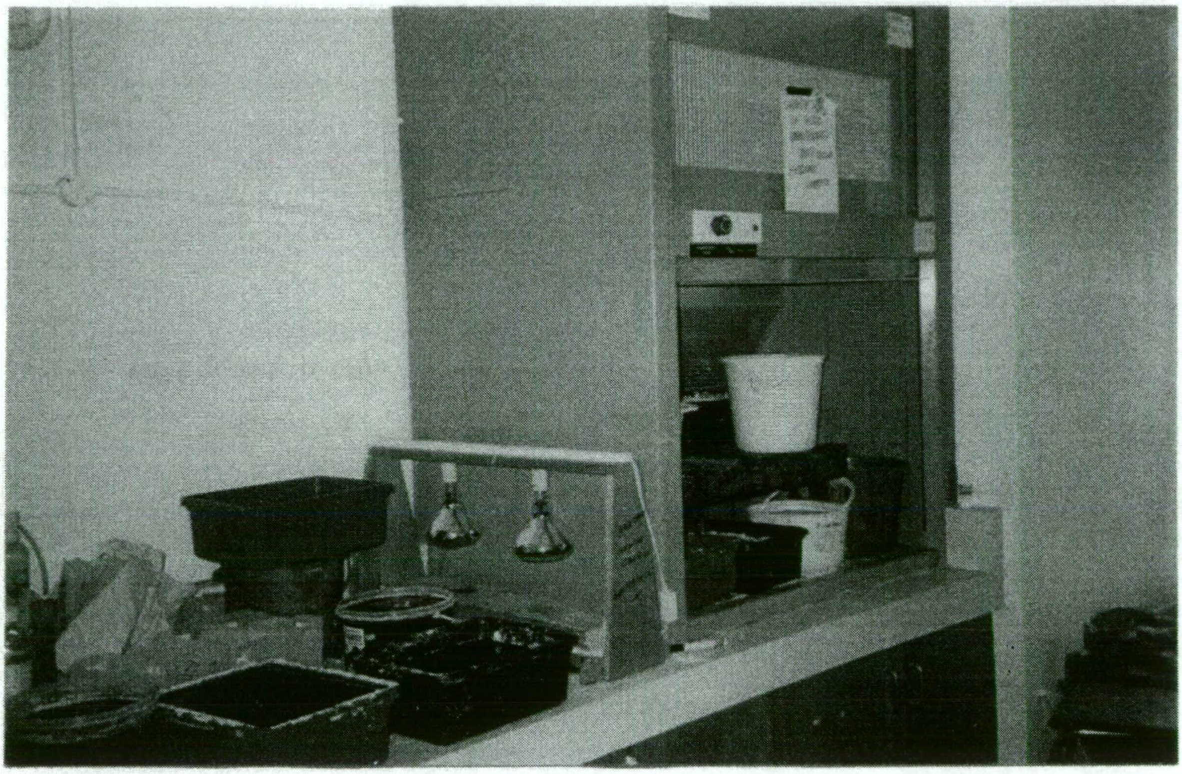
1. A fume cupboard should be available.
2. A good working space is needed.
3. A stand to allow two levels of leaching trays.
4. A drying stand using light bulbs as shown in Photograph 12.1. and Fig. 12.2. (See Separation Process 12.1.3.17 below).

12.2.1. Each sample should be crushed to smaller pieces to increase the surface area for acid leaching. The rocks samples should then be scrubbed under with a soft laundry brush to remove any soil, lichens, moss or vegetable material that may pollute the acid leaching solution.

12.2.2. Each sample taken from a particular section in the field was placed in plastic dishes. Rectangular containers are the most useful as they are easier to store side by side in the fume cupboard during the acid leaching process. They are also easier to write on. (See 12.3.2.3 below).

12.2.3. The side of the container was clearly marked with:

i. The name of the section.



Photograph 12. 1. Acid leaching laboratory and the lamp system for drying sediments.

ii. The day, the date and the time that the acid was added to the limestone sample.

iii. A spirit pen was used to indicate the above as other pens are often water soluble.

12.2.4. Approximately 1 litre of buffer solution is added to each dish containing the limestone samples. The solution can be obtained from previously used acid solutions. This solution is usually stored in large plastic garbage tins. The pH of the buffer solution should not exceed 3.6. A higher pH may cause a deterioration of some conodont specimens over time (JEPPSSON et al., 1999, p. 963).

12.2.5. The buffer solution is then further diluted with water until the container is approximately three–quarters full.

12.2.6. Two litres of acetic acid is then added to each container.

12.2.7. The solution is topped up during the week unless a sample of the residue is removed for study.

12.2.8. A reasonable sample can be expected after a week of leaching especially after a first wash of sediment has occurred. The first wash will give you an idea of how productive the sample being leached might be. It also helps to remove a lot of debris that may not have been removed by an earlier scrubbing.

12.2.9. Each dish should be marked with the day and the date that they will be examined for residues. e.g. Mon 3/2/ a.m. Wed. 5/2/ p.m. This date will also enable you to plan the next washes in advance and also ensure that you have not taken a sample from the dish earlier than planned.

12.3. The Washing of sediments obtained from the Acid Leaching Process.

12.3.1. Excess solution is decanted back into the garbage tin containing the buffer solution. This solution is available for future acid leaching of limestones.

12.3.2. The remaining rock sample is washed thoroughly in the dish and drained through a sieve into a plastic bucket. While in the sieve the rock material is washed again to remove any conodonts that may not have passed through the sieve into the bucket.

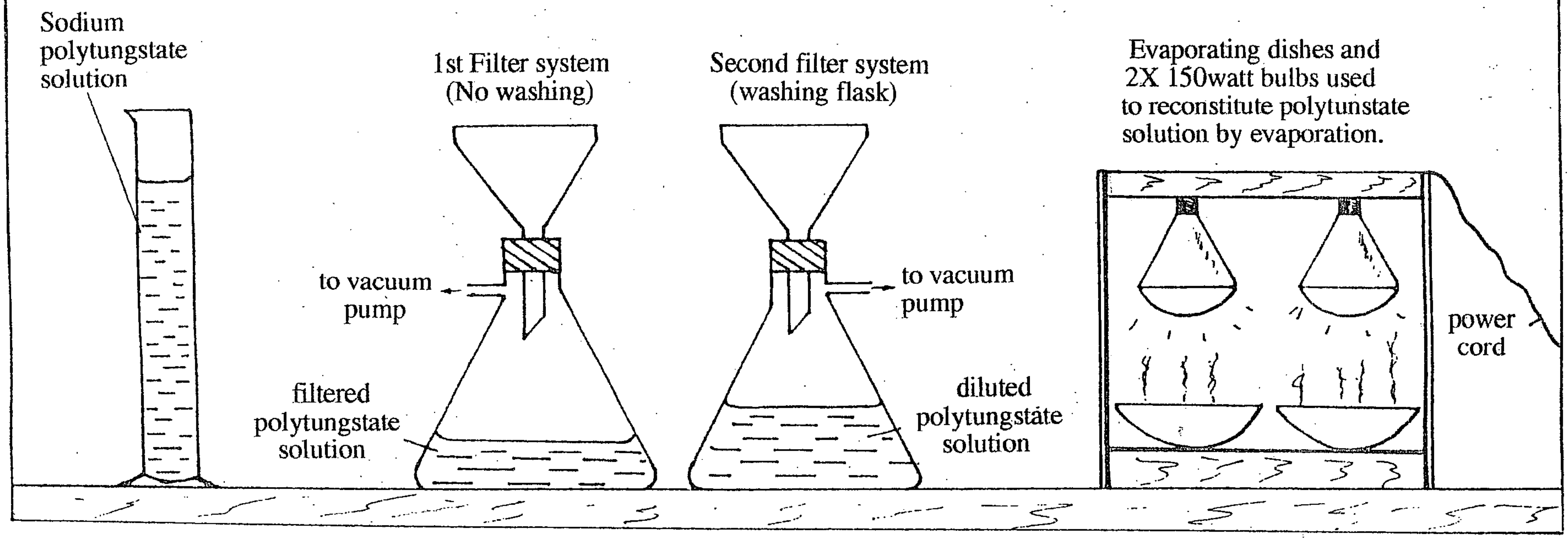
Stub name: - - - - - - - - - - - - - -

Film No. - - - -   Date: - - - - - - - - - -

No.		Time	No.		Time
1		Size X	6		Size X
2		Size X	7		Size X
3		Size X	8		Size X
4		Size X	9		Size X
5		Size X	10		Size X

Fig. 12.1

Fig. 12.2. Separation of sediments from acid leaching using Sodium polytungstate solution.



12.3.3. Much of the water covering the sediment is decanted out of the bucket. The sediment is then washed through a finer sieve (1mm approx.). The residue that does not pass through this sieve is discarded. The remaining sediment is washed thoroughly and any light material such as clays are washed out.

12.3.4. The heavier sediment is retained and washed into an aluminium container with sides approximately 4 to 5 cm high. Excess water is decanted from this container and it is labelled with a piece of paper indicating the section from which it was obtained. e. g. KARM 35 or K.L. 35.

12.3.5. All samples are washed with deionized water and placed on a tray which will be put in a drying cupboard. Washing with deionized water will remove Ca^{2+} which may contaminate the sodium polytungstate used in the separation of conodonts from the residues.

12.3.6. The remaining rock samples may be placed back into clearly marked plastic bags for storage. If a particular section is particularly productive in providing conodont specimens it should be put through the acid leaching process again to obtain additional specimens.

12.3.7. All specimens in the aluminium trays are then placed into the drying cupboard to dry the specimens.

12.4. The separation of conodont specimens from sediments by the use of sodium polytungstate solution.

12.4.1. Introduction.

The following procedure has been successfully used for the extraction of conodont specimens from samples in acid residues which were obtained by the acid leaching process. The procedure has virtually replaced the use of bromoform in the separation process. Bromoform has inherent dangers due to the carcinogenic nature of the fumes and should be used within a fume cupboard DÉGRADIN (1975). Sodium polytungstate does not limit the time that a researcher should be in close proximity to the solution (MORROW & WEBSTER 1989 and ANDERSON et al., 1995)

12.5. Preparation of the sodium polytungstate solution.

12.5.1. Ensure that all glassware is clean had has been rinsed in distilled or deionised water. This removes any Ca^{2+} ions which may be present in tap water.

12.5.2. Wash the acid residues with distilled or deionized water.

12.5.3. Mix the sodium polytungstate with deionised or distilled water in the ratio of 4 units of sodium polytungstate to 1 unit of water by volume. 100gm of sodium polytungstate in 250 ml water should make approximately 500ml of sodium polytungstate solution.

12.5.4. Add sodium polytungstate to the water or add water until the specific gravity of the solution is within the range of 2.76–2.79. Test with an hydrometer.

12.5.5. Store in a large measuring cylinder and cover the top of this cylinder to keep dust out of the solution.
N.B. a piece of calcite or a calcite crystal can be used to determine the sp. g. of the sodium polytungstate solution. The correct sp.g. occurs when the calcite crystal floats in the solution.

12.6. The Separation Process.

12.6.1. Prepare 8 seamless Harris brand coffee filter papers with the edges no higher than 3 cm above the base of the Buchner funnel. 4 filter papers will be used for the light fraction and 4 will be used for the heavier fraction.

12.6.2. Label the filter papers as necessary for each particular sample to be separated. Use a pencil in preference to a water soluble pen. After the separation each sample will have a light and a heavy fraction

12.6.3. If you have a centrifuge take four tubes that will fit into a centrifuge machine (36mm diameter are suitable) wash them in deionized water and fill them to approximately $^1/_3$ with sodium polytungstate solution.

12.6.4. A sample of the sediment is added to the solution in each tube and then each tube was filled to approximately $^1/_2$ with more solution. The sample and the polytungstate solution are swirled to ensure that all of the sample is in contact with the solution. Do not add too much sample as it will be difficult to saturate the sample and get the conodonts to separate freely from the sediments.

12.6.5. Deal each of the tubes with "Gladwrap" or parafilm and seal with a latex band.

12.6.6. Place the tubes in the centrifuge and make sure that the centrifuge is properly balanced by checking that the tubes have similar amounts of fluid and sample.

12.6.7. Run the centrifuge for 10-15 minutes at approximately 2000 revs/min.

12.6.8. Remove the tubes from the centrifuge and allow to stand for ten minutes in a rack so that the heavier fraction can continue to settle out. The material floating on the top will be the light fraction.

12.6.9. Prepare **two** vacuum filtering systems as shown in Fig. 12.1. The filtering of residues under a vacuum requires a plastic filter disc under the filter paper.

12.6.10. Pour off the liquid from one tube time into the **first** filtering system. This will be the **light fraction** or the material floating on the surface of the tube. Rotate the tube as you pour so that as much of the light fraction as possible will be removed. Turn on the vacuum pump and filter until the paper is reasonably dry.

12.6.11. The paper containing the light fraction is placed in the second filtering system and washed with deionised water. This step is important so that only one filtered solution of polytungstate will be diluted and need reconstituting.

12.6.12. The **heavy** fractions can then be filtered by carrying out the same process. Pour the heavy fraction into the first filtering system and filter under a vacuum.

12.6.13. Remove the filter paper containing the heavy fraction and place into the second filtering system and wash all of this fraction using deionised water from a squeeze bottle.

12.6.14. Repeat the above process for all of the other samples to be separated.

12.6.15. Allow the filter papers to dry on paper towelling on a bench. When the samples are dry bottle each sample. Label each with the section name and indicate whether they are light or heavy fractions.

12.6.16. Light fractions should be retained as they may contain specimens of sponge spicules, foraminifers, ostracods or crinoid ossicles (YAKOVLEV & SHTERENBERG 1967). If conodonts are present they should be found only in the heavy fraction.

12.6.17. As the sodium polytungstate is very expensive all filter papers and paper towelling should washed with distilled water. This solution and the other filtered solutions are then reconstituted to the correct specific gravity under gentle heat. An easily constructed piece of apparatus suitable for this process is shown in Fig. 12.1. Each bulb is a 150 watt, 240v pearl or clear bulb. The heat produced by these two bulbs is sufficient to control the slow evaporation of the diluted polytungstate solution.

12.7. Extraction of Conodonts.

12.7.1. Conodonts can be physically extracted from the heavy fraction by means of a binocular microscope. Cover the bench with white paper as camel hair brushes used in the extraction may come in contact with the side of the petri dish and the conodont specimens may flick of the brush. The specimens are more easily located on white paper.

12.7.2. The heavy fraction is poured into a glass or plastic petri dish in small amounts for examination. Pour the sediment onto a petri dish in a thin "line" so that the sediments can brushed apart carefully as you work up along the "line" of sediment. A productive sample can also be spread thinly out in a petri dish and the edge of the dish raised one to two cms and dropped several times. This small vibration often separates the conodonts from the sediments fairly readily.

12.7.3. Another quicker technique is to have a separating tray with another tray under it. Conodonts are pushed through the holes of the upper separating tray with a fine camel hair brush as they are located.

12.7.4. Prepare some specimen slides by spraying with flat white paint. The conodont specimens are easier to see on a white surface when they have been transferred from the sediment.

12.7.5. Conodont specimens can be moved to a slide marked with the Section name by using a fine, moist, camel hair brush.

12.7. 6. The conodonts should be stuck onto the slide with a water soluble gum. This make the elements more secure and easier to examine later.

12.7.7. A moist brush can used to dissolve the gum when the conodonts are being moved onto a stub for photography through an electron microscope.

12.7.8. A double sided sticky tape can be used to stick the conodonts onto the small stubs.

12.7.9. Fig. 12.1. is an example of a stub Book record that should be kept for each conodont photographed. The circle in the top left hand corner is the record of the conodonts on the stub. Sketch the positions of some conodonts for reference later. Some electron microscopes will not allow you to photograph all of the conodont specimens on the stub at once. It's a handy reference later. Write the name of the section on the edge of the stub. (e.g. KARM 3.0)

12.7.10. Stubs should be filed in a covered box. Screw in a flat piece of wood with holes in it to take the stubs. A square grid pattern is best (Fig. 12.2.)

12.8. Photography.

12.8.1. All images were taken through an Electroscan Environmental Scanning Electron Microscope housed at the Department of Chemistry, University of Tasmania, Hobart.

12.8.2. All photographs should be recorded in a Stub book which record a sketch of the conodont, the date and time it was taken, the location and if possible a sketch or photograph of the conodonts on the entire stub. See diagram. Fig.12.1.

12.8.3. Ilford FP4 Plus 125 black and white film can be used for the production of the negatives from the SEM microscope. This film was found to have the best contrast for conodont photography in the wet mode through the SEM.

12.8.4. All positive images should processed onto Ilford multigrade paper No. 2 as it gave the best contrast for black and white images of conodonts.

12.8.5. The size and date are printed onto the negatives with a black spirit pen. After they have been developed the information appears white on the photograph for easy reference.

12.8.6. Images of conodonts should be retained on a CD so that they can be printed off after scanning and enhancement using a Photoshop programme.

12.8.7. Photoshop.

All images can be enhanced by use of a computer using Photoshop. Most images can now be stored on a CD directly from the Scanning Electron Microscope. The images can be prepared and then arranged to form the Plates.

12.9. Size of Image.

12.6.1. The length of the bar on the SEM negative of print image was taken.

12.9.2. The length of the specimen on the negative or print was also measured.

12.9.3. The length of the specimen was divided by the length of the bar.

12.9.4. The length of the specimen was then converted to mm by multiplying by 100µm.

12.9.5. The result was multiplied by the enlargement factor on the negative or print. (X 30 etc). e. g. 8mm X 60 = 4.8mm.

12.9.6. This factor was written on the negative with black ink before processing so that the factor will appear on the negative.

Formula:

Actual size of the specimen on the stub	X	real length of magnification of the scale on the contact print	=	Length of specimen shown on the negative.

12.10. Suppliers.

Sodium polytungstate ($3Na_2WO_4.9WO_3.H_2O$) is obtainable from

West Germany.	Australia	
SMT SOMETUR	Central Chemical Consulting	IMBROS Pty., Ltd.
Falkenreid 4 D1000 Berlin. 33. West Germany. Telefon 030 831 1950. Telex 0 185 433	Box 40 Karrinyup. Western Australia. 6921.	7 Chesterman St., Moonah. Tasmania. 7009.

Properties of SPT.

1. Specific Gravity = 2.90–2–92.
2. Bulk specific gravity of the solid =2.0 approx.

12.11. Suppliers of other Apparatus (Australia).

12.11.1. Plastic filters for Buchner Funnels. There are 8 sizes 45–240mm. These are distributed by Plastilab Kartell for SEIPER & Co.

12.11.2. Filters Harris Coffee and tea Pty Ltd.

1.71 baskets type in boxes of 1000. Fax 61–2–50 5649.

Information from ANDERSON et al. (1995, p. 520.).

12.12. LST. A new heavy liquid for mineral and conodont separation.

Central Chemical Consulting Pty. Ltd. have advertised new solid LST (containing lithium heteropolytungstate) which is suitable for the separation of conodonts from acid residues. The properties listed below are from their pamphlet on LST.

Properties:

1. An aqueous solution that has a low toxicity.
2. Safe and effective replacement for bromoform, and TBE.
3. Low viscosity and high thermal stability.
4. An operating density of 2.85g/mL at 25°C.
5. A suggested recovery rate of 99% is suggested for LST.
6. A low cost recovery liquid.
7. Thermally stable to 80°C for about two weeks.
8. At a density of 2.85g/mL the viscosity is low and there is less likelihood of recrystallization.
9. Can be stored indefinitely in closed plastic or glass containers.
10. If subjected to very cold conditions the aqueous solution can be dissolved by warming.

The address of Chemical Consulting Supplies Pty., Ltd is supplied on p. 8 of this Appendix.

Disclaimer:

This process is deemed to be quite safe. The author does not accept liability for any injury or damage to a person or property resulting from techniques outline in the Appendices of this paper.

When using this process all due safety instructions accompanying all liquids and the apparatus used should be heeded. All appropriate clothing and safeguards should be strictly observed and adhered to. These will be set out by the Laboratory and the Department where this type of work might be carried out.

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